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CHARLES F. MARVIN, Chief

MONTHLY WEATHER REVIEW

VOLUME 46, No. 12

DECEMBER, 1918

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NOTICE TO CONTRIBUTORS.

Contributions intended for publication in any given issue of the MONTHLY WEATHER REVIEW (e. g., January) should be in the hands of the editor before the end of the next following month (e. g. February), if no illustrations are required. When the paper is illustrated, the manuscript and the copy for illustrations must be submitted much earlier, in order to permit copy being prepared for the engraver by the end of the month.

REPRINTS are made up without covers in the original size and pagination of the REVIEW. They will not be furnished unless specifically REQUESTED WHEN THE MANUSCRIPT IS SUBMITTED.

MONTHLY WEATHER REVIEW

HERBERT H. KIMBALL, Acting Editor.
CHARLES F. BROOKS, Associate Editor.

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INTRODUCTION.

As explained in this introduction during 1914 the MONTHLY WEATHER REVIEW now takes the place of the Bulletin of the Mount Weather Observatory and of the voluminous publication of the climatological service of the Weather Bureau. The MONTHLY WEATHER REVIEW contains contributions from the research staff of the Weather Bureau and also special contributions of a general character in any branch of meteorology and climatology.

SUPPLEMENTS to the MONTHLY WEATHER REVIEW are published from time to time.

The climatological service of the Weather Bureau is maintained in all its essential features, but its publications, so far as they relate to purely local conditions, are incorporated in the monthly reports "Climatological Data," for the respective States, Territories, and colonies.

Since August, 1915, the material for the MONTHLY WEATHER REVIEW has been prepared and classified in accordance with the following sections:

SECTION 1.—*Aerology.*—Data and discussions relative to the free atmosphere.

SECTION 2.—*General meteorology.*—Special contributions by any competent student bearing on any branch of meteorology and climatology, theoretical or otherwise.

SECTION 3.—*Forecasts and general conditions of the atmosphere.*

SECTION 4.—*Rivers and floods.*

SECTION 5.—*Seismology.*—Results of observations by Weather Bureau observers and others as reported to the Washington office.

SECTION 6.—*Bibliography.*—Recent additions to the Weather Bureau library; recent papers bearing on meteorology.

SECTION 7.—*Weather of the month.*—Summary of local weather conditions; climatological data from regular Weather Bureau stations; tables of accumulated and excessive precipitation; data furnished by the Canadian Meteorological Service; monthly charts Nos. 1, 2, 3, 4, 5, 6, 7, 8, the same as hitherto; Meteorological Summary and chart No. 9 of the North Atlantic Ocean for this month in 1917. Owing to the fact that ocean meteorological data are frequently not available for a considerable time after the close of the month to which they relate, the chart and text matter in connection therewith appear one year later.

In general, appropriate officials prepare the seven sections above enumerated; but *all students of meteorology and climatology are cordially invited to contribute such additional articles as seem to be of value.*

The voluminous tables of data and text relative to local climatological conditions, that during recent years were prepared by the 12 respective "district editors," are omitted from the MONTHLY WEATHER REVIEW, but are collected and published by States at selected section centers. (See cover, p. 3.)

The data needed in section 7 can only be collected and prepared several weeks after the close of the month designated on the title-page; hence the REVIEW as a whole can issue from the press only within about eight weeks from the end of the month.

It is hoped that the meteorological data hitherto contributed by numerous independent services will continue as in the past. Our thanks are due especially to the directors and superintendent of the following:

The Meteorological Service of the Dominion of Canada.
The Meteorological Service of Cuba.
The Meteorological Observatory of Belen College, Habana.
The Government Meteorological Office of Jamaica.
The Meteorological Service of the Azores.
The Meteorological Office, London.
The Danish Meteorological Institute.
The Physical Central Observatory, Petrograd.
The Philippine Weather Bureau.

The Weather Bureau desires that the MONTHLY WEATHER REVIEW shall be a medium of publication for contributions within its field, but such publication is not to be construed as official approval of the views expressed.

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SECTION I.—AEROLOGY.

SOLAR AND SKY RADIATION MEASUREMENTS DURING DECEMBER, 1918.

By HERBERT H. KIMBALL, Professor of Meteorology.

[Dated: Weather Bureau, Washington, D. C., Jan. 28, 1919.]

For a description of instrumental exposures, and an account of the methods of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1918, **46**:2

The monthly means and departures from normal values in Table 1 show that solar radiation intensities averaged very close to normal values at Lincoln, Nebr., and somewhat below at Washington, D. C. At Madison, Wis., measurements were obtained on only one day, the 11th, and these were interrupted by clouds which obscured the sun by 10 a. m. The 27th was the only clear day during the month, and on that day there were some clouds in the morning.

As was to be expected under these cloudy conditions, Table 3 shows a deficiency of radiation for Madison amounting to 33 per cent of the normal amount for December. Lincoln shows a deficiency of 18 per cent, and Washington a deficiency of 14 per cent.

For the year, Washington shows a deficiency of 3,905 calories, or 3 per cent of the normal amount, of which 2,600 calories, or two-thirds of the total deficiency, was lost during the months of April and September. The only decided departure from normal radiation during the year at Madison is that for the month of December. The departures at Lincoln are less regular.

No radiation measurements were obtained at Santa Fe during the month due to a defect in the galvanometer.

Clouds prevented measurements of skylight polarization at Madison. At Washington, measurements on three different days give a mean of 58 per cent, with a maximum of 62 per cent on the 15th. These are close to the average values for Washington in December.

TABLE 1.—*Solar radiation intensities during December, 1918.*

[Gram-calories per minute per square centimeter of normal surface.]

Washington, D. C.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
A. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Dec. 2			1.15							
3			1.29							
5				1.11						
6			1.15	1.07	0.99	0.91	0.75	0.69	0.57	0.49
12				1.07						
17			1.27							
18			1.20	1.24		1.12	1.02	0.98	0.93	0.89
19				0.92	0.85	0.79	0.69	0.59	0.52	
30			1.13	1.07	0.98					
Monthly means			**1.20**	**1.08**	**0.94**	**0.94**	**0.82**	**0.75**	**0.67**	**(0.69)**
Departure from 11-year normal			**−0.03**	**−0.05**	**−0.11**	**−0.04**	**−0.07**	**−0.06**	**−0.07**	**+0.06**

TABLE 1.—*Solar radiation intensities during December, 1918*—Con.

Washington, D. C.—Continued.

Date.	Sun's zenith distance.									
	0.0°	48.3°	60.0°	66.5°	70.7°	73.6°	75.7°	77.4°	78.7°	79.8°
	Air mass.									
	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5
P. M.	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*	*cal.*
Dec. 2				1.10	1.04	0.89				
6				1.00	0.75	0.66	0.59	0.53	0.48	0.42
12				1.05	0.96	0.81	0.74	0.68		
17				1.23	1.14	1.06	0.99	0.91	0.87	0.83
18				1.14	1.06	1.01	0.96	0.91	0.83	0.79
30				1.02	0.94	0.87	0.80	0.74	0.65	0.59
Monthly means				**1.09**	**0.98**	**0.88**	**0.82**	**0.75**	**0.71**	**0.66**
Departure from 11-year normal				**−0.05**	**−0.06**	**−0.06**	**−0.06**	**−0.10**	**−0.07**	**−0.07**
Madison, Wis.										
A. M.										
Dec. 11						1.13	1.09	1.02	0.96	0.90
Monthly means						(1.13)	(1.09)	(1.02)	(0.96)	(0.90)
Departure from 9-year normal						−0.02	−0.05	−0.03	+0.04	+0.01
Lincoln, Nebr.										
A. M.										
Dec. 10					1.22					
11					1.26	1.19	1.13	1.07	1.01	
14				1.34	1.30	1.24	1.17			
25				1.35	1.22	1.10				
29					1.17	1.08	1.00			
Monthly means				(1.34)	1.23	1.15	1.10	(1.07)	(1.01)	
Departure from 4-year normal				+0.04	−0.01	+0.02	+0.07	+0.10	+0.13	
P. M.										
Dec. 10								1.06		0.97
29						1.10	1.06	1.01	0.97	
Monthly means						(1.10)	(1.06)	(1.04)	(0.97)	(0.97)
Departure from 4-year normal						−0.03	−0.02	−0.01	−0.01	+0.03

TABLE 2.—*Vapor pressures at pyrheliometric stations on days when solar radiation intensities were measured.*

Washington, D. C.			Madison, Wis.			Lincoln, Nebr.		
Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.	Date.	8 a. m.	8 p. m.
1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*	1918.	*mm.*	*mm.*
Dec. 2	3.00	4.75	Dec. 11	4.17	4.57	Dec. 10	4.37	3.30
3	4.17	4.57				11	3.00	3.81
5	2.62	2.74				14	3.81	5.16
6	3.63	2.36				25	0.96	1.52
12	5.79	4.95				29	2.87	3.81
17	3.63	2.87						
18	1.96	2.62						
19	3.30	3.63						
30	2.16	3.30						

TABLE 3.—*Daily totals and departures of solar and sky radiation during December, 1918.*

(Gram-calories per square centimeter of horizontal surface.)

Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.			Day of month.	Daily totals.			Departures from normal.			Excess or deficiency since first of month.		
	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.		Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.	Washington.	Madison.	Lincoln.
	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.		cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Dec. 1	188	40	183	15	− 90	− 5	15	− 90	− 5	Dec. 19	182	115	32	26	− 14	−140	− 486	− 563	− 479
2	176	113	224	5	− 16	38	20	−106	33	20	167	19	20	10	−111	−153	− 476	− 674	− 632
3	189	57	242	20	− 72	58	40	−178	91	Decade departure							− 380	− 358	− 632
4	145	109	221	− 22	− 20	39	18	−198	130										
5	188	117	241	23	− 11	61	41	−209	191	21	140	18	66	− 17	−112	−107	− 493	− 786	− 739
6	223	142	157	59	14	− 22	100	−195	169	22	20	23	117	−137	−108	− 57	− 630	− 894	− 796
7	128	145	158	− 35	17	− 20	65	−178	149	23	195	28	53	38	−104	−121	− 592	− 998	− 917
8	117	172	142	− 45	44	− 35	20	−134	114	24	20	37	198	−137	− 95	23	− 729	−1,093	− 894
9	139	17	40	− 22	−111	−136	− 2	−245	− 22	25	178	158	272	21	25	97	− 708	−1,068	− 797
10	66	56	197	− 94	− 71	22	− 96	−316	0	26	190	151	100	32	17	− 76	− 676	−1,051	− 873
										27	122	144	136	− 36	9	− 41	− 712	−1,042	− 914
11	14	101	244	−145	− 26	70	−241	−342	70	28	183	121	218	25	− 15	40	− 687	−1,057	− 874
12	183	85	36	25	− 42	−137	−216	−384	− 67	29	185	45	266	26	− 92	86	− 661	−1,149	− 788
13	39	32	60	−118	− 95	−112	−334	−479	−179	30	216	49	58	57	− 89	−124	− 604	−1,238	− 912
14	44	163	241	−112	36	70	−446	−443	−109	31	70	34	133	− 90	−106	− 51	− 694	−1,344	− 963
15	95	143	228	− 61	16	57	−507	−427	− 52	Decade departure							− 218	− 670	− 331
16	36	69	176	−120	− 59	5	−627	−486	− 47										
17	183	140	29	27	12	−143	−600	−474	−190	Excess or deficiency since first of year.	gr.-cal.						−3,905	−1,190	−1,513
18	244	54	23	88	− 75	−149	−512	−549	−339		per cent						− 3.1	− 1.0	− 1.1

HALO PHENOMENA OBSERVED DURING DECEMBER, 1918.

By WILLIS RAY GREGG, Meteorologist.

Station.	Altitude.	Latitude.	Longitude.	Date.	Form observed.	Time of—		Theodolite readings.					
						Beginning.	Ending.	Time.	Radius inside.	Radius outside.	Length of arc.	Distance from sun or moon.	Altitude of sun or moon.
	m.	° ′	° ′						°	°	°	°	°
*Broken Arrow, Okla.	233	36 02	95 49	16	Solar halo, 22°	2:30 p. m.	4:15 p. m.	3:48 p. m.	21.5	23	360		12.5
				16	Lunar halo, 22°	6:30 p. m.	D. N.						
				17	Solar halo, 22°	8:00 a. m.	8:40 a. m.	8:30 a. m.	21	23	5		10
				17	Parhelion, right, 22°.	8:00 a. m.	8:40 a. m.						
				19	Lunar halo, 22°	D. N., a.	6:25 a. m.				360		
Canton, N. Y.	137	44 36	75 10	2	Solar halo, 22°	2:00 p. m.	2:30 p. m.						
				17	Lunar halo, 22°	10:00 p. m.	10:30 p. m.						
				20	Solar halo, 22°	2:00 p. m.							
				21	Solar halo, 22°	2:22 p. m.	3:00 p. m.						
Cincinnati, Ohio.	191	39 06	84 30	7	Solar halo, 22°	10:00 a. m.	12:30 p. m.						
Dayton, Ohio.	274	39 46	84 10	7	Solar halo, 22°	11:35 a. m.	12:15 p. m.						
*Drexel, Nebr.	396	41 20	96 16	3	Solar halo, 22°	8:28 a. m.	11:12 a. m.	9:48 a. m.	22	23	180		17.5
				6	Solar halo, 22°	8:20 a. m.	10:22 a. m.	8:49 a. m.	22	22.5	180		10
				6	Solar halo, 46°	8:46 a. m.	8:50 a. m.	8:49 a. m.	45.5	46	90		10
				7	Solar halo, 22°	10:17 a. m.	11:38 a. m.	10:32 a. m.	22	23	210		21
				7	Solar halo, 46°	10:28 a. m.	11:05 a. m.	10:32 a. m.	45.5	46.5	45		21
				11	Solar halo, 22°	2:38 p. m.	4:18 p. m.	3:03 p. m.	22.5	23	190		15
				13	Lunar halo, 22°	6:42 p. m.	6:59 p. m.	6:55 p. m.	22	23	360		55
				16	Solar halo, 22°	8:50 a. m.	9:30 a. m.	9:06 a. m.	21	22	160		11
				16	Lunar halo, 22°	7:30 p. m.	10:30 p. m.	7:45 p. m.	21	21.5	360		40
				24	Solar halo, 22°	9:40 a. m.	11:12 a. m.	9:58 a. m.	22	23	180		16
*Ellendale, N. Dak.	444	45 59	98 34	22	Solar halo, 22°	8:05 a. m.	1:00 p. m.	9:40 a. m.	22	23	240		10.5
				30	Solar halo, 22°	2:20 p. m.	4:15 p. m.	2:30 p. m.	22.5	23	275		16
*Groesbeck, Tex.	141	31 30	96 28	9	Lunar halo, 22°	10:00 p. m.					360		
				10	Solar halo, 22°	3:00 p. m.							
				16	Solar halo, 22°	1:00 p. m.							
				16	Lunar halo, 22°	9:00 p. m.					360		
				17	Lunar halo, 22°	8:00 p. m.							
				22	Solar halo, 22°	10:10 a. m.	11:00 a. m.						
				25	Solar halo, 22°	10:55 a. m.	11:00 a. m.						
*Leesburg, Ga.	85	31 47	84 14	9	Solar halo, 22°	10:32 a. m.	12:00 m.				180		
				10	Lunar halo, 22°	6:00 p. m.	8:30 p. m.				360		
				13	Lunar halo, 22°	6:09 p. m.	9:07 p. m.						
				14	Lunar halo, 22°	9:55 p. m.	10:55 p. m.						
				17	Solar halo, 22°	9:27 a. m.	4:30 p. m.	10:00 a. m.			300		
				23	Solar halo, 22°	1:53 p. m.	4:25 p. m.	2:00 p. m.			180		
				23	Parhelion, right, 22°.	2:00 p. m.	2:15 p. m.						
				23	Parhelion, left, 22°	2:00 p. m.	2:10 p. m.						
				26	Solar halo, 22°	3:19 p. m.	3:22 p. m.				2		
				29	Solar halo, 22°	10:53 a. m.	11:27 a. m.	11:00 a. m.			180		
Madison, Wis.	297	43 05	89 23	4	Solar halo, 22°	1:30 p. m.	2:45 p. m.						
				4	Parhelion, right, 22°.	1:30 p. m.	1:35 p. m.						
				4	Parhelion, left, 22°	1:30 p. m.	1:35 p. m.						
				5	Solar halo, 22°	9:50 a. m.	10:25 a. m.						
				7	Solar halo, 22°	9:45 a. m.	10:00 a. m.						
				12	Solar halo, 22°	10:00 a. m.	11:00 a. m.						
				12	Upper tangent arc.	10:15 a. m.	10:30 a. m.						
				17	Solar halo, 22°	10:30 a. m.	11:00 a. m.						
				17	Upper tangent arc.	10:30 a. m.	11:00 a. m.						
				17	Lunar halo, 22°	8:00 p. m.	9:00 p. m.						
				19	Lunar halo, 22°	D. N., a.	6:45 a. m.						
				19	Solar halo, 22°	8:15 a. m.	9:40 a. m.						
				25	Parhelion, left, 22°	3:30 p. m.	4:10 p. m.						
				26	Solar halo, 22°	10:20 a. m.	1:40 p. m.						
Nashville, Tenn.	166	36 10	86 47	18	Solar halo, 22°	1:00 p. m.	1:10 p. m.						
				19	Solar halo, 22°	12:00 m.	2:00 p. m.						
				30	Solar halo, 22°	11:45 a. m.	12:15 p. m.						
*Royal Center, Ind.	225	40 53	86 29	17	Solar halo, 22°	7:58 a. m.	8:40 a. m.						
				17	Solar halo, 22°	11:00 a. m.	11:20 a. m.						
				17	Solar halo, 22°	2:45 p. m.	3:30 p. m.						

*Aerological station.

HALO PHENOMENA OBSERVED DURING DECEMBER, 1918—Continued.

Station.	Date.	Colors.†	Degree of brightness.	Clouds. Amount.	Clouds. Kind.	Clouds. Direction.	Station pressure.	Precipitation. Last previous ended.	Precipitation. First subsequent began.
*Broken Arrow, Okla.	16	R	Dim.	10	Ci. St.	sw.	Stationary.	D. N., a., 14th.	D. N., p., 17th.
	16	R	Bright.	10	Ci. St.	sw.	Stationary.		
	17	R	Brilliant.	5	Ci. St.	sw.	Stationary.	D. N., a., 14th.	D. N., p., 17th.
	17	R	Brilliant.	2	A. Cu.	sw.			
	19	Y	Dim.	5	A. St.	s.	Stationary.	7:30 a. m., 18th.	3:45 p. m., 19th.
Canton, N. Y.	2		Dim.	1 Ci. St. / 6 A. St.	w. / w.		Falling.	8:00 a. m., 1st.	D. N., a., 3d.
	17		Dim.	1	Ci. St.	w.		8:00 a. m., 15th.	8:00 a. m., 22d.
	20		Dim.	3 Ci. St. / 1 A. St.	w. / w.		Falling.	8:00 a. m., 15th.	8:00 a. m., 22d.
	21		Dim.	2	Ci. St.	w.	Falling.	8:00 a. m., 15th.	8:00 a. m., 22d.
Cincinnati, Ohio.	7		Dim.	10	Ci. St.	nw.	Falling.	11:00 p. m., 3d.	9:30 p. m., 8th.
Dayton, Ohio.	7		Dim.	9	Ci. St.	sw.	Falling.	D. N., a., 4th.	D. N., a., 8th.
*Drexel, Nebr.	3	O	Dim.	2 Ci. St. / 7 A. St.	nw. / nw.		Rising.	8:46 a. m., 1st.	3:26 p. m., 8th.
	6	R, O, Y, G, B.	Dim.	7	Ci. St.	w.	Stationary.	8:46 a. m., 1st.	3:26 p. m., 8th.
	6	R, O, Y, G	Dim.	3	A. St.	w.			
	7	O, Y, G, B, I, V.	Bright.	5	Ci. St.	w.	Stationary.	8:46 a. m., 1st.	3:26 p. m., 8th.
	7	R, O, Y, G, B.	Dim.	2	A. St.	w.			
	11	O	Dim.	5	Ci. St.	w.	Stationary.	8:45 a. m., 9th.	9:55 a. m., 12th.
	13		Dim.	4	Ci. St.	sw.	Rising.	D. N., a., 13th.	8:20 p. m., 17th.
	16	O, Y, G, B, I, V.	Dim.	3 Ci. St. / 2 A. St.	wsw. / sw.		Rising.	D. N., a., 13th.	8:20 p. m., 17th.
	16		Bright.	4 Ci. St. / 2 A. St.	sw. / sw.		Rising.	D. N., a., 13th.	8:20 p. m., 17th.
	24	O	Dim.	6	Ci. St.	nnw.	Rising.	2:45 a. m., 22d.	8:08 a. m., 26th.
*Ellendale, N. Dak.	22	R	Dim.	9	Ci. St.	nw.	Rising.	9:00 p. m., 21st.	5:45 p. m., 25th.
	30	R	Dim.	9	Ci. St.	.....	Rising.	(‡)	(‡)
*Groesbeck, Tex.	9		Dim.				Stationary.	6:25 a. m., 8th.	8:25 a. m., 11th.
	10		Dim.				Rising.	6:25 a. m., 8th.	8:25 a. m., 11th.
	16			8	Ci. St.	w.	Falling.	6:55 a. m., 13th.	9:28 a. m., 18th.
	16	R, O, Y, G, B, I.	Dim.				Stationary.		
	17		Dim.				Rising.	6:55 a. m., 13th.	9:28 a. m., 18th.
	22						Rising.	7:25 a. m., 20th.	1:45 p. m., 22d.
	25						Falling.	9:20 a. m., 23d.	11:22 a. m., 30th.
*Leesburg, Ga.	9		Dim.	8	Ci. St.	sw.	Falling.	11:00 p. m., 1st.	6:48 a. m., 10th.
	10		Bright.	10	A. St.	se.	Stationary.	10:30 a. m., 10th.	D. N. a., 11th.
	13		Dim.	10	A. St.	se.	Stationary.	4:00 p. m., 13th.	D. N. a., 14 th.
	14		Dim.	10	A. St.	w.	Stationary.	3:45 p. m., 14th.	6:05 a. m., 19th.
	17	R	Dim.	6	Ci. St.	w.	Stationary.	3:45 p. m., 14th.	6:05 a. m., 19th.
	23	R	Dim.	8	Ci. St.	w.	Stationary.	5:00 a. m., 22d.	D. N. a., 24th.
	23		Bright.						
	23		Dim.						
	26	R, O, Y, G	Bright.	Few. / 9	Ci. / A. Cu	w. / w.	Falling.	1:40 p. m., 25th.	1:00 a. m., 27th.
	29	R. O	Dim.	5	Ci. St.	nw.	Stationary.	4:00 a. m., 27th.	2:44 p. m., 30th.
Madison, Wis.	4		Bright.				Stationary.	7:10 a. m., 4th.	6:15 a. m., 9th.
	4		Dim.						
	4		Dim.						
	5		Bright.	7 Ci. St. / 3 Ci. Cu.	w. / w.		Falling.	7:10 a. m., 4th.	6:15 a. m., 9th.
	7	R	Dim.	6	Ci. St.	w.	Stationary.	7:10 a. m., 4th.	6:15 a. m., 9th.
	12	R	Bright.	10	Ci. St.	sw.	Falling.	6:00 a. m., 10th.	5:10 p. m., 12th.
	12	R							
	17						Stationary.	D. N. a., 14th.	D. N. a., 20th.
	17								
	17		Dim.	10	Ci. St.	w.	Falling.		
	19		Dim.	5	Ci. St.	sw.	Falling.	D. N. a., 14th.	D. N. a., 20th.
	19	R	Bright.	7	Ci. St.	sw.	Falling.		
	25	R	Brilliant.	Few. / 6	Ci. St. / A. St.	w. / sw.	Rising.	8:00 p. m., 24th.	D. N. a., 27th.
	26	R	Bright.	10	Ci. St.	w.	Falling.	8:00 p. m., 24th.	D. N. a., 27th.
Nashville, Tenn.	18	O	Dim.	7	Ci. St.	w.	Stationary.	D. N. a., 15th.	6:00 p. m., 19th.
	19		Dim.	8	Ci. St.	w.	Falling.	D. N. a., 15th.	6:00 p. m., 19th.
	30	O	Dim.	6	Ci. St.	w.	Falling.	12:30 p. m., 28th.	1:45 p. m., 30th.
*Royal Center, Ind.	17		Dim.	5	Ci. St.	w.	Rising.	7:07 a. m., 14th.	D. N. a., 20th.
	17		Dim.	6	Ci. St.	w.	Falling.		
	17		Dim.	6	Ci. St.	w.	Stationary.		

* Aerological station. † Beginning with part nearest sun or moon. R, red; O, orange; etc. ‡ Snowing while halo was observed.

HALO OBSERVATIONS AT YORK, N. Y.

By MILROY N. STEWART, Cooperative Observer.

[Dated: York, N. Y., Jan. 7, 1919.]

Table 1 is in continuation of similar tables in the REVIEW for September, 1915, **43**:444, and September, 1918, **46**:406. Nearly all the lunar halos have been observed between 8 p. m. and 11 p. m., with nearly full moon. This will account, at least in part, for the few observed during the summer months.

TABLE 1.—*Halos observed at York, N. Y.*

A. SOLAR HALOS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual total.
Year 1918	7	8	10	6	4	7	5	10	4	7	4	3	*75
1909–1918, inclusive (10 years), total	54	52	67	50	48	54	49	49	44	51	31	37	586
Mean	5.4	5.2	**6.7**	5.0	4.8	5.4	4.9	4.9	4.4	5.1	*5.1*	3.7	58.6
Smoothed mean	4.9	5.6	5.9	5.4	5.0	5.1	5.0	4.8	4.7	4.4	3.7	4.0	.....

*During 1918, 80 per cent of solar halos were followed by precipitation within 48 hours Average interval was 21.7 hours.

TABLE 1.—*Halos observed at York, N. Y.*—Continued.

B. LUNAR HALOS.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Annual total.
Year 1918.....	0	0	2	0	0	0	0	0	0	2	1	2	**7
1909-1918, inclusive (10 years), total..	14	8	14	6	8	1	1	4	4	7	15	20	586
Mean.....	1.4	0.8	1.4	0.6	0.8	0.1	0.1	0.4	0.4	0.7	1.5	2.0	58.6
Smoothed mean	1.4	1.1	1.0	0.8	0.6	0.3	0.2	0.3	0.5	0.8	1.4	1.7	.....

**During 1918, 4 of the 7 lunar halos were followed by precipitation within 36 hours Average interval was 12 hours.

1918.[1]

January 11. 11:15 a. m..Very bright circumzenithal arc and part of 46°-halo.
February 14. 3:30 p. m .Circumzenithal arc.
February 16.....Circumzenithal arc lasted 9:05 to 9:15 a. m. Solar distance, 46° at 9:10 a. m. Solar distance of north parhelion at 9:15 a. m., 24°.
February 17.....Very bright circumzenithal arc from 9:20 to 9:30 a. m. Bright parhelia and arc tangent to 22° at 9:30 a. m.
February 22. 7:50 a. m..22°- and 46°- (upper arc) halos.
March 11. 7:40 a. m....22°- and 46°- (upper arc) halos, parhelia and circumzenithal arc.
April 22.....22°- halo all p. m. 4:35 p. m.. parhelic circle° complete; southeast parhelion about from 22°- halo; 4:42 p. m. northwest infr4, lateral colored arc.
June 8. 7.26 p. m.....22°-halo, faint, was visible in spite of the solar eclipse in progress at the time, which, together with low altitude of sun, cut down radiation exceedingly. Halo was visible only in part and for but a few minutes.
September 2. 5:30 p. m..Circumzenithal arc and north parhelion.
October 24. 4:43 p. m....Circumzenithal arc. Solar distance to middle of arc=51°. Faint accompanying 22°-halo.

LUNAR RAINBOW AT TATOOSH ISLAND, WASH.

By R. C. MIZE, Observer.

[Dated: Tatoosh Island, Wash., Dec. 15, 1918.]

A complete rainbow was observed here from 4:40 a. m. to 4:50 a. m. this date, more than three hours before sunrise. The sky was three-tenths covered with fracto-cumulus clouds moving slowly from the west, a light sprinkle of rain was falling, the moon's altitude was about 10 degrees and its phase nearly full. The rainbow was very distinct, even where no clouds were visible, and the right extremity was visible below the horizon. The red could be distinguished above the horizon near the right extremity. In other portions of the bow no color could be positively identified, but contrasts were clearly evident throughout its entire length. The rainbow disappeared when rain ceased falling at the station.

WIND ALOFT AT HOUSTON, TEX., DECEMBER 18, 1918.

By Lieut. I. R. TANNEHILL, Signal Corps Meteorological Service.

[Dated: Houston, Tex., Jan. 6, 1919.]

The horizontal projections (on Fig. 1) of the paths of three pilot balloons followed on the morning of December 18, 1918, show possibly a whirl in the atmosphere at an elevation somewhat greater than 1,200 meters. This was not a whirl in the sense of a dust whirl of local significance, but was of great dimensions and persisted for at least two hours. At a height of a little more than 2,000 meters the wind direction was evidently nearly the reverse of that at the surface, and the current at that level was observed from Park Place and Ellington Field (both a slight distance from Houston, Ellington being near Galveston). Irregularities in the amount of wind movement indicated in certain minutes during the rise of the balloons may have been the result of vertical movement of the air, which could not be differentiated from horizontal movement, since but one theodolite was used at either station. In assuming a uniform ascensional rate from formula an error arises in the distance of the balloon when there is an irregularity in the rate of ascent. The diameter of the whirl made by the balloon was about $\frac{3}{4}$ kilometer. This does not represent, however, the magnitude of the whirl in the atmosphere, nor does it prove that there actually was such a whirl.

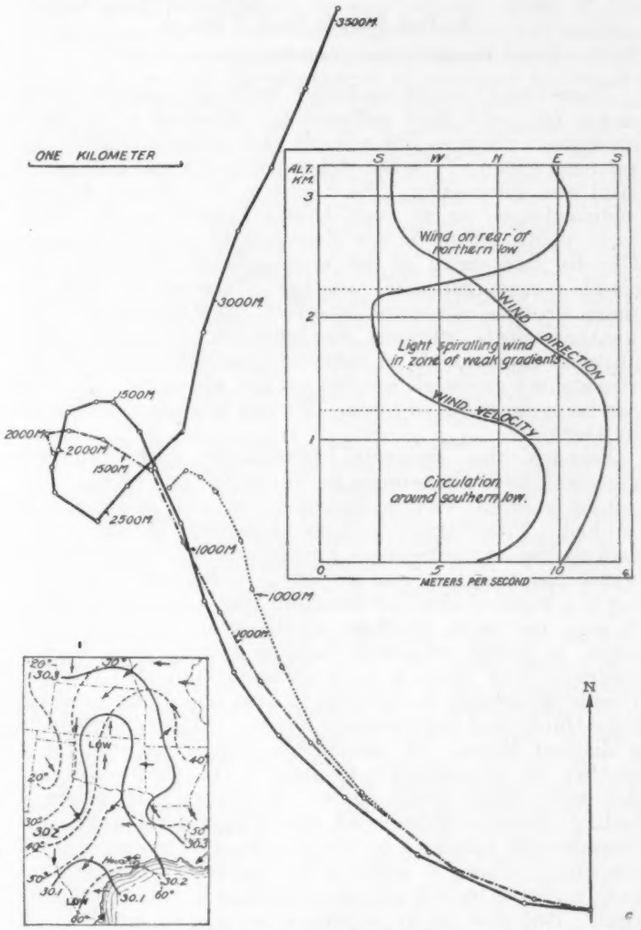

FIG. 1. The long lines represent the horizontal projections of pilot balloon flights, December 18, 1918: Solid line, balloon flight beginning 7.55 a. m., Park Place; dotted line, balloon flight beginning 7:25 a. m., Park Place; dot-and-dash line, balloon flight beginning at 9:33 a. m. at Ellington Field. The small circles show the positions of the balloons at the end of each minute. The figures show the probable altitudes of the balloons at certain points on the projections. The upper inset is a vertical projection of the wind direction and velocity as shown by the horizontal projections. The lower inset is a section of the weather map, 7 a. m. (90th Mer. time), December 18.

Discussion.—The inset diagram shows, in a general way, the changes of wind direction and velocity with altitude as deduced from the horizontal projections of the balloon paths; and the small section of the weather map for 7 a. m. (90th Mer. Time), December 18, shows an east wind in the lower levels circulating around the southern low center, and an upper southwest wind which was associated apparently with the circulation around the center to the north. This upper current was probably colder than the lower one, as is indicated by the colder weather in west Texas, where the winds were probably westerly at all levels. There were heavy rains on the 19th.—*C. F. Brooks.*

[1] All above observations recorded in 75th Meridian Time, except the last four (Apr. 22, June 8, Sept. 2, and Oct. 24), which are recorded in 90th Meridian Time.

SECTION II.—GENERAL METEOROLOGY.

PAPERS ON METEOROLOGY AS A SUBJECT FOR STUDY.

HOW METEOROLOGICAL INSTRUCTION MAY BE FURTHERED.

By Prof. ROBERT DE C. WARD.

[Dated: Harvard University, Cambridge, Mass., Jan. 18, 1919.]

There surely ought no longer to be any need of arguments to prove that meteorology deserves a far more prominent place in our schools and colleges than it has yet been given. The subject is naturally and inherently vital and interesting. Everyone is, in a sense, a born meteorologist, or at least thinks himself such. From early youth, all of us are observers of current weather. Day by day, more or less unconsciously, we make our rough non-instrumental weather observations, and on them we base our own imperfect daily forecasts. The weather affects everyone, whatever his occupation. The physical experiments in nature's great laboratory of the atmosphere go on all around us and above us. No one can be unconscious of them. No one is wholly unaffected by them.

Perhaps this universal familiarity with ordinary meteorological phenomena is, in reality, one of the most potent reasons why meteorology is not more widely studied. Familiarity, here as elsewhere, breeds a certain degree of contempt. People are so accustomed to watch the weather, and so much in the habit of making it a topic of idle conversation, that a serious study of it may not seem to them worth while. A few years since, a highly educated college woman said to the writer: "You have a very difficult subject to teach. People, generally, do not care to hear about things which they think that they already know." The remark gave a distinct shock. It was not a comforting one for a teacher of meteorology to hear. Yet there was undoubtedly much truth in it. It probably expresses a feeling which is widespread, and which must work as a considerable handicap to the extension of meteorological teaching. There is little to be gained by saying that such a view is foolish and narrow minded. It is obviously that. But if it really expresses a state of mind which exists, it must be reckoned with.

There is no subject which, in the hands of a good teacher, can be made more interesting than meteorology; none that gives better training in scientific observational methods; none that develops more logically. It is this gradual development of the subject, when its various subdivisions are systematically arranged and properly coordinated, which is an unfailing source of inspiration to the good student. From the consideration of temperature and its distribution, through pressure and winds and then on to rainfall, there is a natural sequence of cause and effect, increasing in interest at each step, which can not easily be matched in other branches of human knowledge. Meteorology, when properly taught, is not a series of rough blocks, loosely thrown into a pile. It is rather a set of smoothly hewn and closely fitting blocks, held together by the cement of interdependence and correlation, forming a complete, systematic and beautiful whole. To present meteorology as a series of fragments thrown down in haphazard fashion is to do the subject the greatest injustice and to hinder its advancement.

It is the writer's personal view that to set forth elaborate outlines of desired courses of instruction and to try to force these outlines on those who are anxious to teach is not the best method of furthering meteorological education. Such syllabi are more likely to repel than to attract would-be teachers. It is, of course, true that suggestions as to outlines from those who have already had experience in teaching should always be welcomed by others who lack such experience. But, in the long run, the man or the woman who slavishly adopts some one else's outline is not showing the true spirit of the best teacher. Each teacher should develop for himself what his own qualification and his own interests best fit him to do, and what best meets the demands and needs of his students.

Two things are needed: There must be united effort on the part of all those who are already in a position to give instruction in meteorology to send out students who will, in their turn, carry on that instruction. And, secondly, as meteorology has at present a recognized place in very few of our colleges and universities, teachers of physics, of geology, of geography, and of other sciences, who have any interest in meteorology, should make it their business to develop meteorological courses as a part of their own work. The first thing necessary is the interest, and the willingness to do the pioneer work. This will lead to the acquirement of the necessary knowledge. A short elementary course once established in connection with some other subject will soon lead to a demand on the part of the students, for more advanced instruction along the same lines. Thus will well-organized departments of meteorology and climatology gradually come into being.

College presidents are not in the habit of welcoming elaborate schemes for the establishment of courses in new subjects, especially when these courses involve the appointment of new instructors and the purchase of laboratory equipment. But if the demand for such instruction grows up within the walls of the institution from its own students, who have been inspired by good elementary teaching to desire more advanced instruction, then the presidential attitude is almost certain to be hospitable.

Let those who are already teaching meteorology, or who are able to establish new courses in that science, put their very best efforts into that teaching, to make it as supremely interesting and vital as it ought to be and can be made. Then their students who go out to teach, even if their own special field be physics, or geology, or some other science, will, some of them, somehow, find a way to lay the foundations of elementary courses in meteorology. And thus, gradually, without any flourish of trumpets, and without any widespread educational campaign, meteorology will come into its own.

COLLEGIATE INSTRUCTION IN METEOROLOGY.

By CHARLES F. BROOKS, Meteorologist, Weather Bureau.

[Dated: Washington, D. C., Jan. 22, 1919.]

The war-time demand for 600 meteorologists well trained in physics and mathematics showed that there were but a handful of such men available in the United States. Obviously, something had been lacking in our scientific education. The Signal Corps met the immediate situation, first, by having the Weather Bureau give about 200 young engineers and other scientists a preliminary training, which was finished in France; and, second, by establishing in this country a Signal Corps School of Meteorology to train the remaining number needed.[1] The recognition of the importance of meteorology in warfare led to the inclusion of a course of meteorology in the work of the Students' Army Training Corps. Now that colleges are revising their curricula in the light of lessons taught by the war, meteorology is beginning to receive consideration not accorded it before.

In most colleges where the subject is touched upon meteorology is taught in conjunction with physical geography. Therefore the teacher is a geographer or geologist, with, perhaps, but little knowledge of the physics of the air. In his hands, the course is, necessarily, mostly descriptive. The textbook describes and illustrates, the lecturer may add some personal notes and interpretations; and the laboratory assistant presides over simple exercises, such as observing and reducing the readings of instruments, and constructing and describing isothermal or isobaric maps. The course usually ends with a trip to the local office of the Weather Bureau. "Interesting and easy" is the students' universal verdict. Some take the elementary course; few or none push themselves into advanced work, in which no instruction is offered.

In some of the larger universities, meteorology and climatology are taught together in the department of geography. Here the instructor knows and teaches his subject well, although he may not be enough of a physicist to make his meteorology a course as rigorous as physics. Much of the emphasis is climatological rather than physical, for meteorology is taught as the forerunner of climatology, or as a background to geology and geography. The enthusiastic student is drawn more easily into the regular advanced courses in regional climatology than into the research course or courses which offer the only advanced work in meteorology.

In a few colleges, meteorology is taught in the department of physics. The association is all that could be desired;[2] but, unfortunately, there are few physicists who know meteorology well enough to teach it satisfactorily. In most branches of physics, the laboratory work is work of precision carried on indoors under carefully controlled conditions. Some experiments in meteorological physics can be conducted in the laboratory; but the vast majority of the experiments are conducted by Nature in such a way that man can only observe processes and results without being able to control the conditions of the experiments.[3] As the geologist and geographer work largely in the open, they generally know more about the weather than does the physicist, and so are better prepared to teach meteorology than is the physicist.

The content of meteorology is easily described as *the weather and its elements*. A college course in meteorology may well include the following lines of work: (1) Daily instrumental and non-instrumental observations to be recorded in a graphical, consecutive picture of the weather, and to be discussed briefly; (2) a systematic study of meteorology as a branch of physics, presented mostly by lectures; (3) laboratory study of instruments; various exercises; and practice in the construction of weather maps and in forecasting; and, possibly, (4) one or more special papers on meteorological topics.

The work should extend over as long a period as practicable. If it is confined to less than two months, neither the students nor the teacher can be satisfied with the abbreviated presentation of the subject. Even if the students devote all their time to meteorology, two months is too short to get an intimate knowledge of the weather; for to understand the weather it is necessary to observe its various phases, not once, but many times. The obvious general arrangement for a study of meteorology would be to observe the weather carefully day after day while investigating, first, each element separately, and, second, the weather as the combination of these elements.

(1) *Daily observations.*—Beginning with the first meeting of the course, the instructor should establish the regular practice of spending five minutes with his class in the open for observing the weather every time he has any of his students assembled. At the first session of the course each student may be started making and recording simple weather observations. Observe the amount of cloudiness, the wind, the occurrence of rainfall, and the visibility. At first, it will be sufficient detail to record the cloudiness as "cloudy," "partly cloudy," or "clear," the wind direction to the nearest of eight points, the velocity in such terms as "calm," "light," "moderate," "strong," and "gale." In recording rainfall, the times of beginning and ending, with, perhaps, some note as to the intensity of the rain, may be sufficient. Visibility is usually expressed in terms of the distance at which well-defined objects are visible.[4]

It will hardly be found practicable to have the students take observations at times other than those when assembled for classroom or laboratory work, although they may be encouraged to make optional observations three times daily, morning, afternoon, and evening. At each meeting with the instructor the students should be asked to make their individual observations and hand them to the instructor. Then the instructor will read his observations aloud and give a brief explanatory talk on the weather since the last observation and on what the local signs indicate for the next few hours. The observations may be marked and returned to the students at the next meeting, and then they can enter them in a notebook. The tabulation of these observations may be made graphical by the use of the international symbols, repeating what is indicated in words or abbreviations. Arrows flying with the wind and having one to four double barbs, according to the velocity, may be used for the wind symbols.

Observations of temperature and pressure may soon be added. These observations can not very well be taken by each student more than once daily, if as often as that, but the observations made by any one can be posted and used by all to make graphs similar to the records of the thermograph and barograph.

[1] See M. W. R., Dec., 1918, 46: pp. 560-562.

[2] See the introductory part of Prof. W. J. Humphrey's paper, "Some recent contributions to the physics of the air," Science, 1919 (M. W. R., Dec. 1918, 46: 563-564).

[3] Prof. W. S. Franklin has discussed this in detail in "A much needed change of emphasis in meteorological research," M. W. R., Oct., 1918, 46: 449-453.

[4] The best publication on visibility is that by Sir Napier Shaw: "Memorandum on Atmospheric Visibility." Published for the Naval Meteorological Service Hydrographic Dept., [British] Admiralty, Feb., 1918, 8°, 18 pp. (Abstract is to be published in a later issue of the M. W. R.)

By the time the subject matter of the course reaches "clouds" the daily meetings with the instructor in the open will have acquainted the students with the different cloud forms sufficiently to enable them to make these observations individually. The clouds occurring at different elevations should be recorded separately, the highest clouds at the top. Where two or more cloud forms occur at the same level, as is frequently the case when there is a sheet of alto-stratus fringing off into strato-cumulus and alto-cumulus, it is well to use only the abbreviation of the dominant type. For each cloud type the number of tenths of the sky covered should be

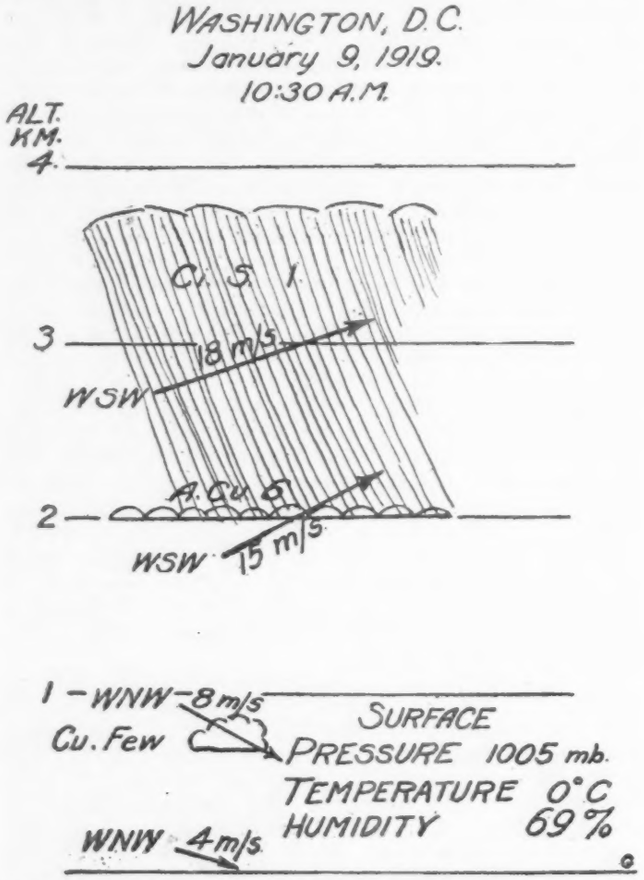

FIG. 1.—Graphic cross-section of the lower air. The diagonal streaks marked "Ci. S." represent that the snow crystals of which the cirro-stratus cloud was composed fell to a considerable distance below the top of the cloud, and in many places even fell through, and partially obscured the layer of alto-cumulus below. The directions of the arrows are entered as if on a map, and their lengths are roughly proportional to the wind velocity. The indicated altitudes of the Ci. S. and A. Cu. are hypothetical.

recorded, and a little later the direction of movement from the nearest of 16 points should be observed and entered.

With the consideration of winds in the systematic work of the course, the students' observations may be refined still further. Once a week or oftener, when clouds at several levels are visible, each student should make for himself a detailed meteorological observation, including pressure, temperature, humidity, wind direction and velocity, cloud direction and relative (angular) velocity, and from this he should construct a diagrammatic cross-section of the conditions at different elevations in the lower atmosphere. Except for the observations of pressure, temperature, and humidity, no instruments are required. The direction of the wind and of the clouds at the different levels should be observed to the nearest of 16 points. The velocity of the wind may be estimated according to the Beaufort scale and then converted into meters per second. If the altitude of a cloud is estimated, using the average or most frequent altitude of the cloud form as a guide, and if the angular rate of movement, say, in fractions of a radian per minute is observed, even without instruments, cloud velocities may be obtained with fair accuracy by simple trigonometry. The altitude of bases of cumulus clouds may be computed by the "dew-point formula," and the heights of the tops or other features may be obtained by proportional measurements.[5] The results of this observation may be shown graphically on a diagram as in figure 1.

The students' observations of clouds, winds, and miscellaneous phenomena may be recorded in some such form as the following:[6]

NON-INSTRUMENTAL WEATHER RECORD.[7]

C. F. BROOKS, COLLEGE STATION, TEXAS. JULY, 1918. 90th Mer., "SUMMER TIME."

Date.	8 A. M. Clouds and Wind.† Amt. 0–10	Kind.	Dir.	2 P. M. Clouds and Wind. Amt. 0–10	Kind.	Dir.	8 P. M. Clouds and Wind. Amt. 0–10	Kind.	Dir.	Remarks. Rain, Haze, Miscellaneous Phenomena.
8	0	0	0	2	Cu.	ENE	2	Ci. S.	NE	Vis. 5 km. at 2 P.
							2	S.Cu.	ENE	
	○	Lt.	W	○	Mod.	ESE	◑	Mod.	SE	
9	4	Ci.S.	NE	1	Cu.	NE	2	Ci.S.	S	Vis. 6 km. at 2 P.
							2	A.Cu.	NW	Vis. 10 km. at 8 P.
							4	Cu.N.	SSE	◎ 6:00–6:15 P.
	◑	Lt.	NW	○	Lt.	N	●	Mod.	SE	
10	4+1*	Ci.S.	NNW	3	Ci.S.	{NNW S	1	Ci.	NNW	Vis. 9 km. at 2 P.
							3	Ci.S.	S	
	Few.	Ci.Cu.	NNE			{N (top) S (base)				
	5	S.Cu.	SSW	5	Cu.		2	S.Cu.	NE	⊕ 4-5 P.
	●	Lt.	SE	◑	Lt.	N	◑	Mod.	SE	

† Under each date the wind is indicated on the last line: "Lt. W" is light west wind.
* When an upper cloud layer is surely more extensive than those parts of it visible at one time, the additional amount of such a sheet of clouds may be indicated after a plus sign following the number of tenths actually visible.

With the beginning of the consideration of cyclones and anticyclones the individual weather records may be discontinued in favor of a single one for the class as a whole. On a long roll of wrapping paper 3 feet or more wide the instructor, with the help of his students, should keep a detailed graph of the weather, continuing day after day. The form shown in figure 2 is offered as a suggestion. Such a graph made on a large scale and discussed each day will go far toward unifying the students' conception of the weather as made up of a great many elements which are closely interdependent.

As the last advance in the open-air observations by the individuals of the assembled class, individual forecasts from local signs may be handed to the instructor instead of the usual weather observations.

This program of open-air observations is essentially that evolved at the Signal Corps School of Meteorology.

(2) *Lectures.*—Three general outlines of courses in meteorology may be of interest. One is an elementary

[5] Detailed discussion of cloud forms, and methods of observing cloud velocities are contemplated for a "Cloud number" of the MONTHLY WEATHER REVIEW, to appear in three or four months.
[6] This form is, of course, recommended only for purposes of instruction and not for keeping the records of an observatory.
[7] This is a true cloud record, but only approximate for surface winds and miscellaneous phenomena.

course of general meteorology, in which physics is emphasized and climatological aspects are given some attention; a second is a course solely on the physics of the air; and a third is a course of general meteorology which is largely physics of the air, and which has more emphasis on immediate applications, such as forecasting, than on climatology.

The first outline is that of Prof. R. De C. Ward's lectures at Harvard. His course is open to anyone in the university, and so must be presented without a presumption of knowledge of much physics or mathematics on the part of all members of the class. Nevertheless, the physics of the atmosphere is given all possible attention considering (1) that this course is taken by students specializing in geography and geology rather than in physics, and (2) that this course is a prerequisite for the courses in general climatology, regional climatology, instruments, and research in meteorology and climatology.

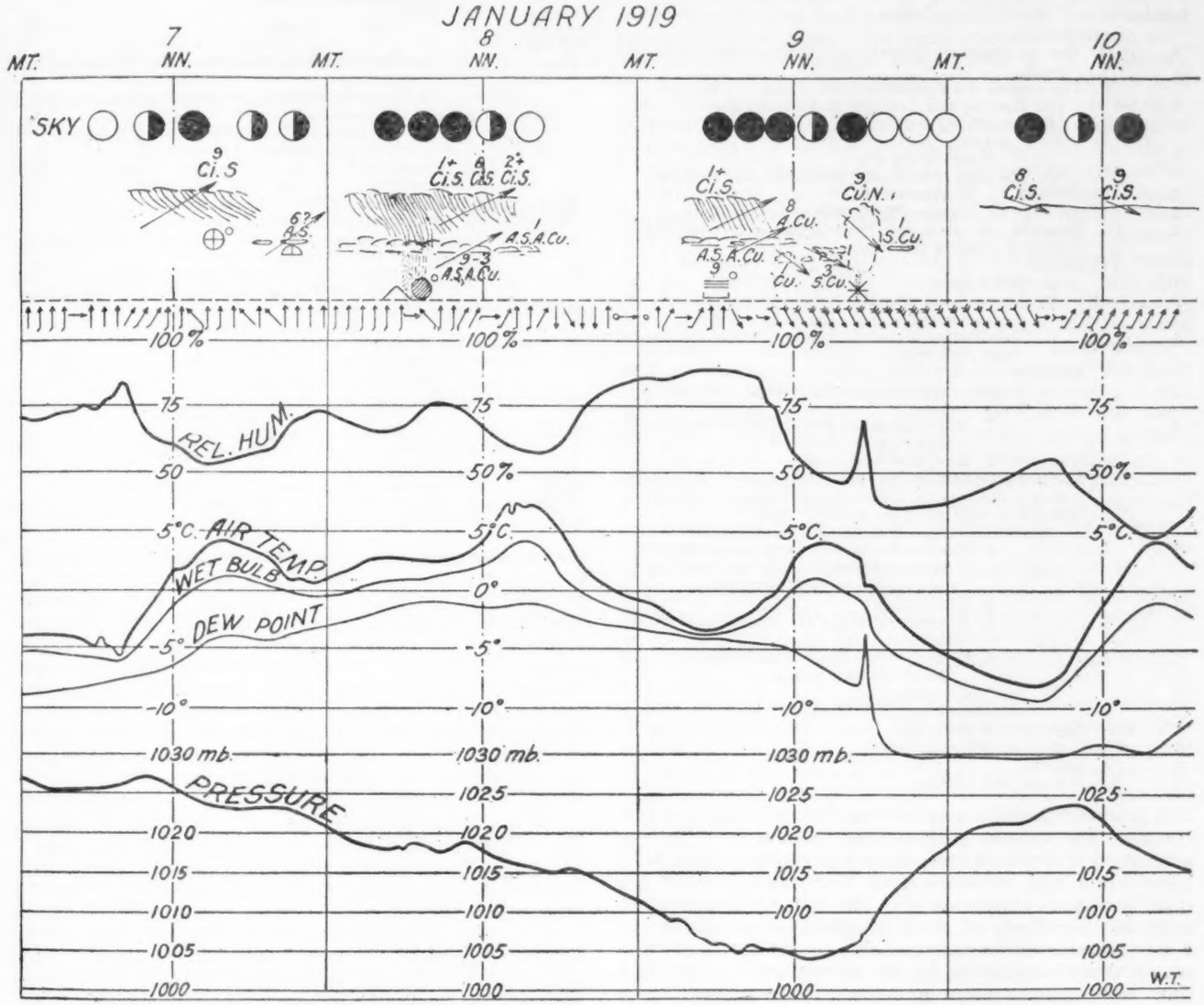

FIG. 2.—Wall chart of the daily weather. Cloud observations made at Washington, D. C., by C. F. Brooks, supplemented by transcripts and computations from instrumental records at the Central Office of the Weather Bureau.

Clouds and miscellaneous phenomena.—International symbols and abbreviations have been used. Actual measurements of the clouds not having been made, their apparent relative heights are indicated, and some attempt has been made to portray their appearance. Since the clouds move generally from the west, and since in most weather or other continuous time diagrams, the later dates are to the right, it is best to represent the clouds as if projected on a vertical plane south of the observer. The directional arrows are drawn as if on a map (as in Fig. 1).

Winds.—Hourly directions and velocities (one barb for each Beaufort number) are shown as if on a map, the arrows flying with the wind.

Relative humidity was taken from the hygrogram corrected by psychrometer observations thrice daily.

Temperatures.—*Air,* from corrected thermogram; *Wet bulb* and *Dew point,* from the thrice daily psychrometer observations, with intermediate values obtained by humidity tables from the hygrogram and thermogram.

Atmospheric pressure was plotted from the trace of a mercurial barograph. After the temperature and pressure curves were drawn, the scales were converted to read in degrees centigrade and in millibars, respectively.

GENERAL METEOROLOGY.

OUTLINE OF THE ELEMENTARY COURSE AT HARVARD UNIVERSITY.

By Prof. R. DE C. WARD.

Lectures.	Outline.
	Introduction.
2....	I. The atmosphere: Extent and arrangement about the earth.
	II. The control of atmospheric temperatures by the sun:
1....	A. Heating and cooling of the atmosphere.
	B. Radiation, conduction, convection, mixture by winds.
1....	Colors of the sky.
	C. The measurement and distribution of temperature.
3....	1. Thermometry.
2....	2. Charts of temperature distribution.
2....	III. Pressure. Barometers. Pressure changes. General relations of pressure and winds.
	IV. Winds:
1....	A. Instruments.
2....	B. Convectional circulation and its applications.
1....	Deflective effect of the earth's rotation.
4....	C. Classification of the winds, and discussion of general and local winds.
	V. Moisture:
1....	A. Sources, evaporation, measurement, distribution.
	B. Condensation.
4....	1. By radiation and conduction, by mixture, by expansion.
2....	2. Dew, frost and clouds.
1....	VI. Vertical temperature gradients: Distribution of temperature in the free air: Adiabatics and retarded adiabatics.
	VII. Winds and weather of our weather maps:
	A. Extra-tropical cyclones and anticyclones.
1....	1. Characteristics of cyclones and anticyclones: At the surface and aloft "gradient wind;" actual paths of cyclonic winds.
2....	2. Forecasting.
1....	3. Theories of origin of cyclones and anticyclones.
1....	4. Special types of winds associated with cyclones and anticyclones.
2....	B. Tropical cyclones.
2....	C. Thunderstorms.
1....	VIII. Atmospheric electricity.
2....	IX. Tornadoes and waterspouts.
2....	X. Rainfall.
1....	XI. Weather and climate.

A few points which may seem arbitrary in the arrangement of the subject matter deserve mention. A consideration of vertical temperature gradients is left until after winds and moisture have been taken up, for the distribution of temperature in the free air depends not only on the effects of sunlight, radiation, and conduction, but also on convection and the latent heat from water vapor condensing in the atmosphere. Tornadoes and waterspouts seem unnecessarily separated from thunderstorms, with which they are almost, if not quite, invariably associated; atmospheric electricity, however, surely requires treatment just after thunderstorms. Rainfall is not discussed immediately following evaporation and condensation, for the distribution of rainfall depends largely on cyclonic and thunderstorm action, which precipitate the moisture from the atmosphere. Prof. Ward's very logical arrangement of his lecture material is the outcome (by no means final) of his extensive experience in teaching general meteorology.

The second outline is that of Prof. W. J. Humphreys's partially published work, the Physics of the Air,[8] which has been followed essentially by the author in two presentations of a course on this subject to Weather Bureau men.

[8] Journ. of the Franklin Inst., 1917 and 1918. See notice in this issue of the MONTHLY WEATHER REVIEW, 1918, 46: 562.

THE PHYSICS OF THE AIR.

GENERAL OUTLINE OF A WORK COMPILED FOR THE WEATHER BUREAU AND PUBLISHED* BY COOPERATION WITH THE FRANKLIN INSTITUTE—USED IN AN ADVANCED COURSE OF INSTRUCTION AT WASHINGTON.

By Prof. W. J. HUMPHREYS.

Divisions on basis of 40 units.	Outline.
2.....	I. Observations. Sources of meteorological information.
	II. Temperature:
1.....	A. Some theoretical temperature relations of the atmosphere.
1.....	B. Observed vertical temperature gradients.
2.....	C. Isothermal region, or stratosphere.
2.....	III. Composition of the atmosphere. Barometric hypsometry.
2.....	IV. Insolation.
	V. Atmospheric circulation:
1.....	A. Introductory: Vertical convection; classification of winds.
1.....	B. Winds due to local heating, local cooling, or both.
	C. Winds due to widespread heating and cooling.
4.....	1. Wind in general. Gradient wind.
1.....	2. Monsoons. Trade winds.
3.....	3. Cyclones and anticyclones.
1.....	4. Forced winds. Tornado.
1.....	VI. Barometric fluctuations.
	VII. Moisture:
2.....	A. Evaporation and condensation.
2.....	B. Fogs and clouds.
3.....	VIII. The thunderstorm and its phenomena.
1.....	Lightning.
1.....	IX. Atmospheric electricity.
6.....	X. Optics.
3.....	XI. Factors of climatic control.

It will be noted that this outline contains no reference to anything but the processes of the atmosphere; the geographical distribution of temperature, humidity, cloudiness, and rainfall are not discussed; and neither are applications of meteorology dwelt upon. The order, which at first sight looks irrational, is adjusted to the observer's point of view. First, how do we observe the phenomena of the atmosphere? Second, what are the features of that most obvious element, the temperature of the air? Third, why do we have such temperatures? The answer to this third question involves the composition of the atmosphere, and insolation. The composition of the upper air can not be discussed without a consideration of barometric hypsometry, so this is introduced here. After temperature, the circulation of the atmosphere, which depends on pressure differences induced by the uneven distribution of temperature, demands attention. Then barometric fluctuations, which are caused by winds, may be introduced. Moisture comes next. Finally, each of the elements having been considered, that highly complex phenomenon, the thunderstorm, is treated in detail. Lightning leads to atmospheric electricity; then follows optics; and a consideration of the factors of climatic control closes the work.

The third outline is essentially that employed at the Signal Corps School of Meteorology, at College Station, Tex., in 1918. Of Division VIII, only the section on aeronautical meteorology was touched on in these Signal Corps courses. The outline was arranged originally for college upper classmen; then modified for sophomores at Yale; and, finally, in the form here presented, used with classes of mature men, most of whom were graduate engineers, the rest being largely physicists, mathematicians, chemists, science teachers, and Weather Bureau observers.[9]

* Except divisions X and XI.

[9] See the article on the Signal Corps School of Meteorology, on pp. 560-562 of this issue of the REVIEW.

GENERAL METEOROLOGY.

OUTLINE OF COURSE AT THE SIGNAL CORPS SCHOOL OF METEOROLOGY, COLLEGE STATION, TEX., 1918.

By CHARLES F. BROOKS.

Lectures.	Outline.
1.....	Introduction: Meteorology.
2.....	I. Physical properties of the atmosphere.
	II. Temperature:
2.....	A. Sunlight and radiation.
4.....	B. Course of temperature on land and water surfaces and in the overlying air.
3.....	C. Vertical and geographical distribution of temperature.
1.....	III. Atmospheric pressure:
1.....	A. Vertical decrease of pressure. Hypsometry.
1.....	B. Pressure changes.
	IV. Winds:
1.....	A. Convectional circulation.
2.....	B. Gradient wind.
1.....	C. Wind friction and its results.
	1. Vertical increase of velocity in the lower air.
	2. Gustiness.
	3. Diurnal period of velocity and direction.
1.....	D. Pressure distribution and winds of the world.
	V. Moisture:
2.....	A. Water vapor; evaporation, humidity, and condensation.
3.....	B. Clouds: Forms and their genesis, heights, velocities; prognostics.
2.....	C. Precipitation: Causes, forms, distribution.
	VI. Weather:
3.....	A. Cyclones and anticyclones, considered as units.
2.....	B. The weather around and in cyclones and anticyclones.
3.....	C. Local storms; thunderstorms, squalls, tornadoes, and waterspouts.
3.....	VII. Weather forecasting.
1.....	VIII. A. Aeronautical applications of meteorology.
1.....	B. Agricultural, engineering, business, and commercial aspects of the weather.
1.....	C. Physiological effects of weather and weather changes.

In content, this course is between Prof. Humphreys's and Prof. Ward's; there is less physics than in the former and less climatology than in the latter. The arrangement is simpler than either of the other two, although this simplicity may be at the expense of the best presentation of the elements in their logical interrelations.

These three outlines are not recommended for adoption, but are presented as examples, in the hope that they may prove helpful to those who teach, or are about to reach, meteorology.

In preparing the lectures, the instructor will find Prof. Humphreys's "Physics of the Air" invaluable; and he will do well to have at hand the text and reference books mentioned below. Such magazines as the MONTHLY WEATHER REVIEW, Geographical Review, Science, Nature (London), Scientific American and Supplement, should be watched so that the most recent advances in meteorology may be summarized and incorporated in the lectures, thereby keeping them full of immediate interest. Similarly, the students should be encouraged to bring in meteorological clippings from magazines and newspapers. Lecture note-taking may well be encouraged, or better still, required. If diagrams are to be incorporated in the notebooks, it is almost essential that the instructor draw them on the blackboard during his lecture. Carefully prepared diagrams, prints, or photographs are excellent illustrative material, but the student will be discouraged by their finished character from attempting a sketch which he may not be able to complete without losing some of the lecture. Lantern slides are more convenient than wall charts and enlarged photographs, but a class will not take notes in a darkened room. Slides may be used, nevertheless, to good advantage in review lectures.

There is as yet no suitable textbook for the general course in meteorology. Prof. W. M. Davis's, Elementary Meteorology,[10] though published 25 years ago is today the clearest and most logical book for teaching use in any language. For those parts which are now out of date, paragraphs from Prof. W. I. Milham's Meteorology [11] may be substituted. Other works which contain valuable information, but which are not so suitable as textbooks are: W. L. Moore's, Descriptive Meteorology,[12] good for reference; Alexander McAdie's, Principles of Aerography,[13] useful for its discussion of the various lines of advance of meteorology during the last few years; F. H. Bigelow's, Atmospheric Circulation and Radiation, a difficult mathematical treatise[14]; the Weather Bureau's, Introductory Meteorology [15] issued for the Students' Army Training Corps last fall; the British Meteorological Office's, Meteorological Glossary [16]; Sir Napier Shaw's, Forecasting Weather,[17] and his more extended, voluminous, Manual of Meterology [18]; Julius von Hann's, Lehrbuch der Meteorologie,[19] the most comprehensive bibliographic work on meteorology; and W. J. Humphreys's, Physics of the Air,[20] the most thorough discussion of the physics of the air—of interest to the student who is willing by close application to study the fundamentals of meteorological physics.

(3) *Laboratory work.*—By far the most extensive and systematic set of laboratory exercises in meteorology, is that developed by Prof. Ward at Harvard. Some idea of the scope of these exercises may be had by referring to his book, "Practical Exercises in Elementary Meteorology"[21]; but since this book was published, so much improvement has been made that it is to be hoped that Prof. Ward will publish his exercises as they are today.

Every course in general meteorology should have detailed laboratory work (1) in meteorological instruments, observations, and forms; (2) in interconversions of temperature and pressure and linear units in conjunction with mapping and graphing the horizontal and vertical distribution of temperature, pressure, and moisture; (3) in the interrelations of the weather elements leading to making and verifying weather forecasts from local observations and weather maps.

(4) *Special reports* on topics chosen by each student for himself and presented orally to the class will serve the double purpose of making the individual a specialist in at least one phase of the subject, and of showing the class that meteorology is a growing science.

The student who does creditable work in a good college course in meteorology, even if this course extends over only one term, will have the basis from which he can make himself a meteorologist. He will know something of how to observe and record the weather; he will be able to interpret to some extent the phenomena of the atmosphere; and, if need be, he can forecast the weather with moderate success. He will not be an expert meteorologist, but he will know how to become one.

[10] Boston, 1894, 4°, 355 pp.
[11] New York, 1912–1917, 4°, 459 pp., 50 charts.
[12] New York, 1910, 4°, 344 pp., 45 charts.
[13] Chicago, 1917, 8°, 318 pp. For discussions, see Science, 1917, N. S., vol. 46, pp. 264–266, and 360; Geog. Rev., 1918, V, pp. 167 and 256.
[14] See mention on p. 563 of this issue of the REVIEW.
[15] New Haven, 1918, 8°, 149 pp. See review on pp. 562–563 of this issue of the REVIEW.
[16] See mention on p. 563 of this issue of the REVIEW.
[17] London, 1913, 8°, 380 pp., 159 figs.
[18] Cambridge, 1919, pts. 1–3 not yet issued; pt. 4, 4°, 160 pp.
[19] Leipzig, 1915, 3d ed., 4°, 847 pp., diagrams, tables, plates.
[20] Loc. cit.
[21] Boston, 1899, 8°, 199 pp.

The demand on the part of artillerists, aviators, and many other military units for weather information and forecasts has demonstrated that meteorology is a subject worthy of the time of more than a mere handful of investigators. The growth of aviation alone and the promise it holds points to a quick rise of interest in the study of the physics of the air. Students who desire to specialize in meteorology need no longer be told that the master or doctor of meteorology must look forward to probable unemployment in his chosen field of work.

Specifically, what are some of the lines of work demanding services of meteorologists? Business, farming, transportation, aviation, research and teaching all need men who know meteorology. Large business concerns have men who constantly watch the weather from the point of view of its effects on their work. For example, general merchandise and hardware concerns buy stock with a view to the probable demand for the different lines several months later; a demand which for many lines of goods is closely dependent on the weather. Without making a study of present and probable weather,[22] these concerns would lose much by having an excess of one kind of stock and not enough of another.

Every farmer is his own local forecaster, and usually he is a good one, for his outdoor life and his direct interest make him familiar with the weather. A large farming corporation, however, needs more than the indications from local signs. A meteorologist to direct the farming, storing and shipping operations would save much produce in the course of the year, and would be able to have the goods reach the markets at the times when prices are best. At Medford, Oreg., in 1912, the fruit growers employed their own frost expert.

Railroads, particularly street-railway companies, have every reason to want in the traffic department a man who knows some meteorology.[23] The question frequently arises, "Snow is forecast for to-night—shall I hold 1,000 men ready to clear the tracks? They would be needed only if the fall exceeds 2 or 3 inches." Motor-truck freight companies in their operations depend considerably on the weather.

In aviation, the wind directions and velocities at different elevations are of great concern. For instance, a wind of 60 miles an hour is to be sought if it blows toward the aviator's goal; but avoided otherwise. To keep informed of the winds of the free air all over the United States will require observations of pilot balloons a few times daily at perhaps 100 places.[24] To chart, and to study these observations will require the work of a large number of men. The openings for aerologists are limited only by the expansion of flying.

The highest specialists in meteorology are needed for research work and teaching. Some subjects worthy of research are indicated in the list on pages 566–567 of this issue of the REVIEW. Research workers would be supported mostly by the universities,[25] by business men, or by the Weather Bureau. To meet the growing demand for meteorologists, there is imperative need of an increasing number of teachers of meteorology.

[22] See "Relation of weather and business in regard to rainfall," Special bulletin, Chamb. of Comm. of the U. S. A., Washington, D. C., Feb. 14, 1919, 4°, 12 pp.

[23] Every November the New York Central Railroad issues a "Chart of mild and cold winters," for the winter guidance of maintenance of way engineers and rolling stock superintendents. The Sixth Annual Weather Issue (by P. H. Dudley, consulting engineer, rail, tires, and structural steel, New York, Nov. 14, 1918), contains a letter; a table of monthly mean temperatures at 16 stations; a chart of departures of monthly temperatures from these means, 1911–1918; and a mention of the operating character of each winter.

[24] There are now only about 30.

[25] In the American Meteorological Journal are articles by Cleveland Abbe on "The needs of meteorology" (1893, XI; 560–562), and "Meteorology in the university" (1896, XII; 312–317), which call for the endowment of universities for meteorological work on a scale commensurate with astronomy; and which outlines a thorough course in such an establishment.

A SIGNAL CORPS SCHOOL OF METEOROLOGY.[1]

By OLIVER L. FASSIG, Chief Instructor, Signal Corps, U. S. Army.

[Dated Washington, Dec. 25, 1918.]

The value of an intimate knowledge of weather conditions—actual and prospective—in war operations is obvious. The many practical applications of this knowledge in artillery fire, in aviation, in gas and flame attacks, in bombing expeditions, and in many other military and naval operations, have received special attention during the past year in the Signal Corps of the Army. One of the duties of the Science and Research Department of the Army is the supervision of all research and development work in meteorology, under the direction of Lieut. Col. R. A. Millikan. By special mention this includes the furnishing of information of surface and upper air conditions to all branches of the Army, and the training of all meteorological personnel.

Early in the fall of 1917, a meteorological section of the Science and Research Department was planned and steps were immediately taken by Col. Millikan, in cooperation with Prof. C. F. Marvin, Chief of the Weather Bureau, to form an organization to provide for the necessary special training of approximately 1,000 men, and for procuring the essential instrumental equipment for stations. The only existing source from which trained weather observers could be drawn was the United States Weather Bureau. As the bureau had already contributed a considerable number of its observers to various branches of the military and naval service, any additional withdrawals would seriously cripple the essential work of the Bureau. Hence plans were made for the special induction of the needed men into the Signal Corps for training and service as weather observers.

As time was a matter of prime importance, the first contingencies of inducted men were sent to a score or more of Weather Bureau stations, located in all sections of the country, in groups of two or three, to eight or ten. Here they were given practical instruction for a period of eight to ten weeks in the duties of observing and recording weather conditions, in the preparation of forms, in the use and theory of instruments, and in the preparation and interpretation of weather maps, under the supervision of the official in charge of the station. In this manner about 200 men were prepared for duty overseas and in this country between September, 1917, and April, 1918. Upon arrival in France the men were given an additional short course in review and in such new applications of their knowledge as were developed at the front.

The instruction at the stations of the Weather Bureau was intended only as a provisional plan to obtain quick results. Early in the spring of 1918 a special school for the training of the men was organized, as it was evident that better results would doubtless be obtained, and with less inconvenience to the Weather Bureau, by standardizing the course of instruction and collecting into one school and under one instruction staff as many men as could be satisfactorily provided for under existing conditions. The first class was organized at Camp McArthur, Waco, Tex., in April, 1918. Before completion of the organization the school was transferred to the Agricultural and Mechanical College of Texas, at College Station, in the latter part of May, 1918. The instruction staff consisted of:

Dr. Oliver L. Fassig, Chief Instructor and Director.

Dr. Charles F. Brooks, Instructor in general meteorology and cloud observation.

[1] Read at the Baltimore meeting of the Association of American Geographers, Dec. 28, 1918.

Mr. William T. Lathrop, Instructor in instruments, observations, and weather maps.

Lieut. William S. Bowen, Instructor in aerology.

The character of the men of this first school of meteorology organized for war work may be of some interest. In the call for men for this service Col. Millikan emphasized the need of men with a college training and especially of such as had a knowledge of mathematics and the physical sciences, or were trained as civil, electrical, or mechanical engineers. As a result there was brought together at College Station, Tex., a class of about 300 enlisted men from 21 to 31 years of age, excellently equipped, mentally and physically, to be converted into observers during a brief period of intensive training occupying about three months. Practically all of the men were either college graduates or had had several years of training as observers in the United States Weather Bureau. Over 100 of them were civil engineers; about 75 were mechanical or electrical engineers; 20 were chemists; about 40 were trained observers from the Weather Bureau; and 30 or more were teachers of science and mathematics. Altogether about 100 colleges were represented including all of the larger institutions of the country. Much valuable assistance was given by the best equipped of these men, who were made assistant instructors.

The men were housed in modern college dormitories, and provisioned at the college mess hall; while President Bizzell and his colleagues of A. and M. College made most liberal provision in the way of class rooms and equipment by placing the civil engineering building at the disposal of the school.

The men were kept busy at their studies and daily military tasks from sunrise until 5 p. m., with an additional study hour or two between supper time and taps. Military administration and instruction were provided for by four commissioned officers of the Signal Reserve Corps, with Lieut. Hjalmar B. Hovde as commanding officer, assisted by Lieuts. A. M. Lindsay, A. W. Hall, and E. A. Wagner. The daily schedule of technical studies included a lecture in general meteorology or aerology; frequent daily cloud studies in the field; the construction and interpretation of the daily weather map, based upon telegraphic observations, for forecast purposes; daily observations such as are made at a first order station of the Weather Bureau; the preparation of meteorological and aerological forms; and thorough practical field instruction in the use of a theodolite for determining the paths of small rubber balloons filled with hydrogen, for determining the velocity and direction of the winds to great elevations above the ground.

The aerological work, dealing with upper air conditions, particularly interested most of the men, especially the engineers. The high grade of men composing the class made it possible to suggest many new mechanical devices and to develop new and quick methods of reducing observations for determining the ballistic wind—methods which will prove to be of great practical value to the artillery units of the Army. The results of their work will not only give more accurate values for the atmospheric factor in firing, but will greatly reduce the time required in obtaining these values—matters of utmost importance in operations at the front. The projectiles fired from the big modern guns not only cover a horizontal distance of 30 to 40 miles, but they traverse the upper atmosphere to heights of many miles. The projectiles of the super-gun which was trained upon Paris at a distance of 72 miles must have reached an elevation of from 30 to 35 miles, exceeding the greatest elevation reached to date by means of pilot balloons. Wind velocities along the path of projectiles may vary from a few miles to 40 or 50 miles and more per hour, and the upper winds may be directly opposite in direction to those below. It is evidently necessary to know accurately the conditions through which the projectile passes, and to get this information quickly. Until very recently it was assumed that surface atmospheric conditions prevailed throughout the path of the projectile, and no allowance was made for the great variations in temperature and density of the air and wind direction and velocity, which actually prevail and which must greatly influence the path of the projectile.

The pilot balloons generally used for this purpose are small rubber balloons, 6 inches in diameter, filled with hydrogen until distended to a diameter of 20 to 30 inches. They are set free, and the position of the balloon in azimuth and altitude is observed at intervals of a minute or more by means of two theodolites placed at the ends of a base line of known length, varying from half a mile to 2 or 3 miles, according to local conditions. This reduces the determination of wind velocity and direction to simple trigonometric computations. These balloons may be observed to great elevations and distances in clear weather. In the latter part of June, 1918, at College Station, Tex., the position of one of these balloons was observed in altitude and azimuth every minute for 172 consecutive minutes, before it faded away, or probably collapsed. It had reached an elevation of 22 kilometers and a horizontal distance of 20 kilometers. The use of such balloons in recent years has added much to our knowledge of varying conditions of the atmosphere up to a height of 25 miles, and to our knowledge of atmospheric processes at great elevations, at comparatively small cost. The knowledge thus gained is of great value to the aviator, especially in selecting favorable air routes, and will aid in the progress of development of aviation to an increasing degree in the near future.

An intimate knowledge of the temperature and density of the air, and of changes in wind velocity and direction, is indispensable for accurate artillery fire, especially in the operation of long range and anti-aircraft guns. Speed in delivering accurate data to the artillery units is of the utmost importance. By means of methods developed at the training school and at the numerous local stations established in connection with artillery and ordnance camps and flying fields in this country, the mean velocity and direction of winds in successive zones of 500 meters may be obtained within less than five minutes after the time the balloon has reached the maximum elevation desired.

One of the important problems, in the solution of of which the members of this class rendered valuable service, was the development of an improved empirical formula for determining the rate of ascent of a balloon from observations by means of a single theodolite in place of two theodolites.[1] This reduces the necessary instrumental equipment and the size of the station force. Much time in reducing observations was saved through the employment of quick graphic methods in computing the ballistic wind in place of the slow and tedious methods of computation previously in use. Another product of the school is a weather map 6 feet long. It is the familiar daily weather map of the United States Weather Bureau, enlarged and modified for classroom instruction. It can be prepared in from one-half to three-fourths of an hour, depending upon the skill of the operator.

[1] To be discussed in an early issue of the REVIEW.

At the time of the signing of the armistice about 300 men, trained at Weather Bureau stations and at the school of meteorology in Texas, had been sent overseas; and about 200 men were assigned to a score or more of the flying fields, artillery and ordnance camps, balloon schools, and radio detachments in this country, for the purpose of supplying these branches of the Army with the meteorological data desired. A score or more of the graduates of the school who are stationed at headquarters in Washington engaged in the reduction of field observations, in the charting of upper air currents, and in necessary administrative duties. Twenty-five of the members of the class were transferred to the Navy for duty in connection with the development of the hydrophone, an instrument designed to detect the presence of submarines.

The School of Meterology was not a unit of the Students' Army Training Corps. It was organized and maintained under the direct supervision of the Chief Signal Officer of the Army.

NEW METEOROLOGICAL BOOKS.

Physics of the Air.

The most thorough American work on general meteorology which has appeared for many years is Prof. W. J. Humphreys's, Physics of the Air. Part I, on Mechanics and Thermodynamics of the Atmosphere (also, atmospheric electricity), was published [1] in 14 installments, making 402 pages, in the Journal of the Franklin Institute, 1917 and 1918. Some 300 copies of Part I will be made up in book form. The purpose of the work is to present a comprehensive, explanatory statement of the physics of the air; one which may form the basis for new courses in meteorology in college and university departments of physics. Much of the argument is developed by the author; in fact, almost without exception the formulas used are derived in the text. Where further information might be of value, Prof. Humphreys not only has given detailed references to the comprehensive literature on meteorological physics contained in the Weather Bureau library, but he has also incorporated digests of these articles and works in his discussion. Thus the reader does not need to look up the references unless he wishes to make a special study in any line.

The scope of the book is all that is implied in the title, the physics of the air. In the first chapter, the sources of meteorological information and the interrelations of the meteorological elements are discussed and illustrated. Then follows, chapters 2 to 6, a careful mathematical exposition concerning the temperature, composition, and heating of the atmosphere. Particular attention is paid to adiabatic changes, to the vertical distribution of temperature,[2] and to the cause of the isothermal condition of the stratosphere.[3]

The middle third of the book, chapters 7 to 10, comprises a thorough exposition of the winds, which are classified according to their immediate causes: (1) local heating; (2) cooling; (3) local heating and cooling; (4) widespread heating and cooling, and (5) external force. Group 1 includes sea breezes and valley winds. Group 2 comprises land winds, mountain winds, and all sorts of fall-winds. Group 3 is of thunderstorm winds. Group 4 involves cyclones and anticyclones, continental winds, and the planetary circulation of the atmosphere; and group 5 includes forced winds, tornadoes, and the foehn. Although each teacher of meteorology will prefer to make some changes in this classification, probably by combining groups 1 and 2, at least, this new classification of winds on the basis of immediate causes has been found better for instruction than a classification based on the original source of energy.[4]

Chapter 11, on barometric fluctuations, contains an explanation of barometric "ripples" and a rather full description and explanation of the diurnal and semidiurnal pressure changes.[5] In chapter 12 the author presents in some detail the rather intricate subject of evaporation and condensation. Fogs and clouds, in chapter 13, are discussed too briefly to do justice to these visible signs of atmospheric processes; the explanatory descriptions and the carefully selected cloud pictures are well worth double the space accorded them. The thunderstorm, in chapter 14, receives the space appropriate to such a commanding phenomenon. It is considered as a whole, and each of its elements, especially lightning,[6] are treated in detail. In the following chapter, the scattered results of investigations in atmospheric electricity are bound together. A detailed outline of the history of the development of our knowledge of the subject is given in the first two pages. Then follow in succession brief, though explicit, treatments of the electrical field of the earth, the electrical conductivity of the atmosphere, ionic content of the air, electrical currents in the atmosphere, radioactive content of the atmosphere, penetrating radiation, and origin and maintenance of the earth's charge. A brief discussion of the aurora closes Part I.[7]

Since the present edition is so limited the work is not yet readily available. Nevertheless, Prof. Humphreys has made it no longer necessary to go to works in a foreign language for books on advanced meteorological physics. A review in Nature (London, May 23, 1918, p. 231) says:

> For the large number of readers interested in the fundamental facts of meteorology, there has, up to the present, been no trustworthy text-book which discussed the subject from so scientific a viewpoint or dealt with its modern developments so completely.—C. F. B.

Manual of Meteorology.

Part IV of a voluminous manual of meteorology by Sir Napier Shaw has just appeared (Cambridge, England, 1919).[8] In the preface the author mentions the contents of the different parts to be as follows: I, A general survey of the globe and its atmosphere; II, The physical properties of the air; III, The dynamical and thermal principles upon which theoretical meteorology depends; IV, The relation of the wind to the distribution of barometric pressure. A more extended notice of this work will be published in a later issue of the REVIEW.—C. F. B.

Introductory Meteorology.

As a text or reference book for the Students' Army Training Corps, Introductory Meteorology was written by officials of the Weather Bureau at the request of Prof. H. E. Gregory, representing the National Research Council. The manuscript was prepared in a fortnight in August, and the book appeared from the Yale University Press in October, 1918. (8vo., 149 pp., 71 figs., $1 gross.) Chapters I, the Atmosphere; part of IV, Atmospheric Pressure; V, Evaporation and Condensation; and VI, Fogs and Clouds, are taken largely verbatim from Prof. Humphreys's, Physics of the Air; and Chapters VII, Atmospheric Optics, and VIII, General Circulation of

[1] Published by the Franklin Institute in cooperation with the Weather Bureau.
[2] Cf. pp. 564-565 of this issue of the MONTHLY WEATHER REVIEW.
[3] Cf. p. 564 of this issue of the MONTHLY WEATHER REVIEW.
[4] Cf. W. M. Davis, Elementary meteorology, Boston, 1894, p. 112.
[5] Cf. p. 565 of this issue of the MONTHLY WEATHER REVIEW.
[6] Ibid., pp. 565-566.
[7] Cf. the outline and discussion of the arrangement of the work as a whole, ibid., p. 558.
[8] Pts. 1-3, not yet issued, pl. 4, 4°, 160 pp.

the Atmosphere, were prepared specially by Prof. Humphreys for this book. Chapter II, Measurement of Meteorological Elements, by S. P. Fergusson, is a brief discussion of instruments and methods of observaton. Chapter III, Atmospheric Temperature, by W. R. Gregg, is a well-illustrated discussion of the subject; which, however, would be easier to grasp if part 2 preceded part 1. The section on vertical distribution of temperature is based largely on the most recent data collected in the United States.[9] Prof. J. Warren Smith prepared the brief chapter, IX, on Secondary Circulation of the Atmosphere. Prof. A. J. Henry's chapter, X, on Forecasting the Weather, is a brief statement of the interesting subject. Chapter XI, Climate, by Prof. C. F. Talman, is likewise by necessity highly condensed. The bibliography contains classified references to the more important works on meteorological topics; though in the references on clouds, Clayton's extensive "Discussion of the Cloud Observations," made at Blue Hill Observatory,[10] and the Weather Bureau's voluminous "Report on the International Cloud Observations" have been omitted.[11]

A book of this nature, put together so rapidly, is bound to show lack of unity and unevenness of treatment. Some teachers have described *Introductory Meteorology* as uninteresting and too difficult for the elementary student. The first point, that it is uninteresting, is founded on the fact that it is practically nothing but meteorology, there being little or no mention of the human applications or effects of the elements discussed; and the second objection, that it is too difficult, is based on the necessarily condensed treatment of some of the more difficult parts. The book was not intended to be complete in itself. The authors, however, may have overestimated the meteorological knowledge of many instructors and the time available to others for preparing supplemental lectures. These objectionable features may be easily remedied if there is a call for a somewhat enlarged edition.

On the whole, the book is filling a demand for a brief book on modern meteorology.[12]—C. F. B.

A Manual of Aerography.

"A Manual of Aerography," issued by the United States Navy, was compiled by Lieut. Commander Alexander McAdie.[13] The book is composed of individual chapters assembled essentially without reference to one another, several of which are taken directly from the compiler's "Principles of Aerography" (Chicago, 1917). There are chapters on fundamental units, formulæ, and tables; but most of the book is made up of brief discussions of the major branches of meteorology. Two of the chapters deal with the effects of meteorological conditions on flying: one, by Prof. W. J. Humphreys, is published here only; while the other, by Capt. C. J. P. Cave, is reprinted from the Aeronautical Journal, London, 1917.—C. F. B.

A Treatise on the Sun's Radiation and other Solar Phenomena.

[In continuation of A Meteorological Treatise on the Circulation and Radiation in the Atmosphere of the Earth and of the Sun, 1915.]

Much of this work deals with the solar constant, radiation, and the application of solar data to short and long range forecasting; therefore, it is of interest to meteorologists, although they can not agree with many of the author's conclusions.[14]

Reviews of the earlier work on atmospheric circulation and radiation [15] have been published by F. W. Very, in Science, December 3, 1915 (N. S., vol. 42, pp. 800–805), by A. McAdie, in Geographical Review, October, 1916 (vol. 2, pp. 323–324), and by H. Bateman in Astro-physical Journal, December, 1916 (vol. 44, pp. 342–344).—C. F. B.

Meteorological Glossary.

[Fourth Issue, London, 1918.]

This valuable publication of the British Meteorological Office constitutes a companion volume to the interesting little primer of practical meteorology known as "The Weather Map." While it contains numerous meteorological definitions, it is not primarily a lexicographic work, but rather a compend of information on various meteorological topics, arranged in alphabetical order. A more extended notice of this publication will appear in a later number of the REVIEW.—C. F. T.

SOME RECENT CONTRIBUTIONS TO THE PHYSICS OF THE AIR.[1]

By W. J. HUMPHREYS, Professor of Meteorological Physics, U. S. Weather Bureau.

There has come to us from ancient times the story of a foolish man who sold his birthright for a mess of pottage, and that story to-day is right applicable to us physicists, except in one important particular—we haven't even got the pottage. No department of learning has a richer birthright than has the department of physics in meteorology—the physics of the air. And yet the few institutions that even profess to teach this subject in any form offer it through the department of geology, or more frequently still, that omniverous department which, for want of a better name, is called the department of geography. Statistical meteorology, if such expression will be permitted, or climatology, is of course of great interest alike to the geologist and the geographer, and this they should teach and in a great measure do teach; but climatology is no more meteorology than descriptive geography, for instance, is geology. Its value is great and unquestioned, but its function, like the function of geography, is merely to describe and not to explain.

Meteorology, on the other hand, is concerned with causes; it is the physics of the air—a vast subject of rapidly-growing importance upon which peace and war alike are becoming more and more dependent. Only yesterday we

> "Heard the heavens fill with shouting,
> And there rained a ghastly dew
> From the nation's airy navies
> Grappling in the central blue;"

and to-day

> "Saw the heavens fill with commerce,
> Argosies of magic sails,
> Pilots of the purple twilight,
> Dropping down with costly bales."

It is therefore no longer an opportunity, a shamefully neglected opportunity, that invites, but an imperative duty that commands our leading institutions to add to the various subjects taught, studied, and investigated in

[9] See "Mean values of free-air barometric and vapor pressures, temperatures, and densities over the United States," by W. R. Gregg, MONTHLY WEATHER REVIEW, 1918, 46: 11–21.
[10] Ann. Ast. Obs. Harv. Coll., 1896, vol. 30, pt. 4, 4°, 500 pp., 17 pl.
[11] By F. H. Bigelow, Report of the Chief of the Weather Bureau, 1898–99, vol. 2, 1900, 4°, 787 pp.
[12] For other reviews of this book, see one by "M." in Science, Dec. 6, 1918, pp. 576–577, and another by R. De C. Ward, in Geogr. Rev., 1919. vol. 7.
[13] Government Printing Office, 1918, 165 pp. 8vo.
[14] Cf. C. G. Abbot, Pyrheliometry and solar radiation, Science, June 21, 1918, pp. 609–610 and F. H Bigelow's reply, Science, Oct. 25, 1918, pp. 417–418.
[15] A Meteorological treatise on the circulation and radiation in the atmospheres of the earth and of the sun. New York, 1915, 431 pp., 78 figs.
[1] Extracts from vice-presidential address, Physics section, A. A. A. S., Baltimore, December, 1918. Published in full, Science, Feb. 14 and 21, 1919, N. S., vol. 49, pp. 155–163, 182–186, 6 figs.

their departments of physics that eminently valuable and fascinatingly difficult branch of geophysics—the physics of the air.

No doubt the great majority of colleges and universities would find it highly impracticable to add a proper course in meteorology to their present long list of electives. Neither is it practicable nor desirable for all of them to teach anthropology, say, despite its fascination, nor even any whatever of the a-to-z kinds of engineering. But it is insisted with all possible emphasis that if taught at all it be taught right—taught as a branch of physics. It is also insisted that there is a growing need, especially in connection with both the science and the art of aviation, for young men who understand the phenomena of the atmosphere. Nor should it be forgotten that when our Army called for men trained in meteorological physics it called in vain—they did not exist. Furthermore, it would be a godsend to our national Weather Bureau if in the future it could secure a larger portion of its personnel from among university graduates highly trained in the subjects with which they have to deal. And, finally, it is insisted that the physics of the air offers many opportunities to the creative scholar, and every university must realize that its paramount duty is the fostering of research and the training of investigators, for in no other way can it meet the growing and compelling demands of a progressive civilization.

It must be admitted, however, that it is not now easy to give a connected course on atmospheric physics, for there is no suitable text, and the isolated articles upon which such a course must needs be based are scattered through the journals from Dan to Beersheba and buried under a babel of tongues. But this is only a difficulty and not, in the face of imperative needs, an excuse. A far greater and very real difficulty has, it is true, confronted most of us, for, until the last decade or less, several important lectures in such a course would of necessity have been restricted to the same brevity as characterizes Horrebow's famous chapter on snakes in his Natural History of Iceland—there aren't any.

Some of these lectures are still unwritten—tantalizing challenges to the skill of the experimentalist and acumen of the analyst—while others have been at least partially supplied, a few of which it will be interesting to review in what follows.

Temperature of the Free Air.

* * * It appears, then, that the average temperature gradient (rate of decrease of temperature with elevation) of the free air is approximately that of a rising mass of saturated air; and for the reasons (*a*) that frequently the air is rising and saturated, and (*b*) that departures from the thus established saturation curve develop but slowly, as explained, and are soon eliminated by its reestablishment.

Isothermal State of the Upper Air.

* * * If the surface temperature of the earth is maintained, as we know it is, by the absorption of solar radiation, it is equally certain that in turn the temperatures of objects in the full flood of the necessarily equivalent terrestrial radiation can not drop to zero; nor, therefore, can the air, generally, cool by convection to a lower temperature than that which this radiation can maintain. These ideas, so simple that they seem hardly worth expressing, embody the fundamental explanation of why the upper air is essentially isothermal.

In addition to being exposed all the time to earth radiation the upper air is also exposed much of the time to solar radiation; but there is abundant evidence that the atmosphere at all levels is far more absorptive of the relatively long wave-length terrestrial radiation than of the much shorter wave-length solar radiation. Hence, in computing from *a priori* considerations, the probable temperature of the isothermal region, or statosphere, as it generally is called, it is sufficient, as a first approximation, to consider the effect of only the outgoing radiation, which, according to the work of Abbot and Fowle of the Smithsonian Institution, is approximately equal in quantity and kind to that which would be emitted by a black surface coincident with the surface of the earth and at the temperature of 259° A. * * * Hence, the problem, as an approximation, is to find the temperature to which an object, assumed infinitesimally small, to fit the case of a gas, will come when exposed to the radiation of a single black plane at a given temperature and of infinite extent. * * * Whatever the nature of the object, since it is exposed to twice as much radiation when between two planes as it is when facing but one, it must, in the former case, both absorb and emit twice as much energy as in the latter. * * * $T_2 = T_1 \sqrt[n]{2}$ * * *. As already explained, the value of T_2 [temperature of the radiating plane] is roughly 259° A., and if [the radiation exponent] $n = 4$, the value for a full radiator, it follows that [the temperature of the object exposed to this radiation] $T_1 = 218°$ A., substantially the value found by observation.

Storm Effects on Temperature Gradients.

* * * Quite contrary to familiar ideas about convection, the ascending air [in cyclones] * * * is relatively cold and the descending air [in anticyclones] comparatively warm. And the stratosphere * * * but further confounds this confusion, for here the temperature relations are again reversed, the warmer air being now over cyclones and the colder above anticyclones.

The relation of the temperatures [of cyclones and anticyclones] to each other, level for level up to the stratosphere, is just the reverse of that which it would have to be if their circulations were of immediate thermal origin. Presumably, therefore, their circulations are largely driven and their temperatures in part mechanically determined.

* * * Now, whatever the origin of the migratory anticyclone, a subject that still requires further investigation, one of its chief features is deep winds from higher latitudes in its eastern portions. These winds, because of the rotation of the earth, necessarily lose more or less of such west-to-east velocity as they previously may have had. They lag in the midst of the general circulation. Hence the prevailing westerlies flow over them as over a mountain barrier. But by this overflow the westerlies produce at least three different effects: (*a*) They load the atmosphere over which they pass and thus increase the pressure from the surface up to near the base of the stratosphere. This increase of pressure in turn forces the loaded air to descend, warming on the way according to the adiabatic gradient of 1° C. per 103 meters (if free from clouds) and thereby raising the temperature at all levels through which it passes. (*b*) They bodily lift the stratosphere, whose pressure thereupon tends to decrease at every level in proportion to the initial pressure at that level—a result that would produce dynamically an equal drop in temperature through-

out the stratosphere. (*c*) By their own dynamical cooling, and at least until the pressure of the upper atmosphere has become readjusted, they establish at the base of the stratosphere a layer of minimum temperature. * * *

Similarly, whatever the origin of the migratory cyclone, another of the many meteorological problems that needs further investigation, one of its chief features is a deep wind in its eastern portions from lower to higher latitudes. In this case the rotation of the earth leads to a speeding up of the eastward component of the velocity. Hence this air may be expected to run forward and up and thus to produce a low pressure to its rear. Because of the upward trend thus given to much of the air in the cyclone, that portion of it below the stratosphere is more or less dynamically cooled. At the same time, the stratosphere bodily drops to lower levels wherever air has been removed from beneath it. Hence its pressure is increased at every level in proportion to the initial pressure at that level and its temperature thereby raised by an equal amount throughout.

Radiation and absorption probably also have some part in determining the temperature conditions and interrelations of migrant cyclones and anticyclones, but the chief cause appears to be purely mechanical, as above explained.

The Law of Wind Increase with Elevation.

The fact that wind velocity generally increases with elevation has long been known * * *. [At levels above the influence of surface disturbances and below the stratosphere] the velocity of the wind varies inversely with its density, or, in other words, * * * the mass flow is a constant. [This] * * * mass flow * * * is directly proportional to the horizontal pressure gradient. * * * From the height of 3 or 4 kilometers above sea level up to that of 8 or 9, the density of the atmosphere is roughly inversely proportional to the altitude. Hence, to this same crude approximation [the horizontal pressure gradient] G is also constant through the given range of levels. Hence the horizontal gradient and, therefore, the mass flow must be roughly constant between the given limiting levels * * *.

Barometric Fluctuations.

Barometric "ripples."—Small pressure changes having amplitudes usually of 0.1 mm. to 0.3 mm. and periods of 5 minutes to 10 minutes, and continuing for hours or even days together, are very common during cold weather. They are not greatly different in magnitude from the well-known wind effects on the barometer, but obviously of different origin, since their amplitude has no relation to the local wind velocity.

Their explanation appears to lie in the fact that whenever layers of air that differ in density at their interface flow over each other long billows, analogous to water waves and generated in the same way, are produced. If, now, the under layer is colder than the upper, as it is during the radiation or surface inversions of winter, and rather shallow, 100 meters to perhaps 500 meters thick, the passage of the air billows, like the passage of waves in shallow water, necessarily produces greater or less corresponding changes in the pressure on the bottom—changes that * * * appear as a series of ripples in the record of a sensitive barograph.

During summer, when air billows rarely form near the surface, though frequently at greater altitudes, especially that of the cirrus cloud, barometric ripples do not appear. This, doubtless, is because wave disturbances in air, as in water, do not penetrate far beneath the wave level.

Semidiurnal pressure changes.—It has been known now for more than two and a half centuries that there are approximately regular daily variations in the height of the barometer that culminate in two maxima and two minima in the course of 24 hours. During particularly calm weather these fluctuations are conspicuous on the current barogram, * * * and always revealed by averages, no matter how masked by storm conditions * * *. * * * [It is evident from the times of maxima and minima, and from the stronger occurrence in the tropics and in summer than in extra-tropical latitudes and in winter] that the daily cyclic pressure changes are somehow the results of temperature changes * * *.

It appears * * *:

(*a*) That the afternoon minimum is caused essentially by overflow from the region where the atmosphere is warmest, or better, perhaps, from the meridian along which the temperature increase has been greatest, toward that meridian along which there has been the greatest decrease in temperature.

(*b*) That vertical convection interferes with the free horizontal flow of the atmosphere, and to that extent dams it up and correspondingly increases the barometric pressure; also, that the time of this interference agrees with the forenoon changes of the barometer, and that its magnitude is of about the proper order to account for the forenoon [about 10 a. m.] barometric maximum.

It remains now to account for the night 10 o'clock maximum and 4 o'clock minimum, both of which appear to depend upon the natural or free vibration of the atmosphere as a whole. * * * All that is needed, apparently, to give the semidiurnal pressure curve is a pressure impulse of the same period, 12 hours, as that of the free vibration of the atmosphere as a whole. And this is furnished by the forced forenoon barometric maximum, followed six hours later at the same place by the forced afternoon barometric minimum. * * *

Atmospheric Electrical Phenomena.

The selected contributions to the physics of the air just reviewed belong to the domains of mechanics and thermodynamics. But there have also been recent contributions to other branches of the subject, especially to atmospheric electricity * * *. * * * The origin of the electric charge of the thunderstorm involves more meteorological phenomena than does any of the others. * * *

Many have supposed that, whatever the genesis of the thunderstorm, the lightning, at least, is a product or manifestation of the free electricity always present in the atmosphere—normal atmospheric electricity. Observations, however, seem definitely to exclude this assumption. Thus, while the difference in electrical potential between the surface of the earth and a point at constant elevation is, roughly, the same at all parts of the world, the number and intensity of thunderstorms vary greatly from place to place. Further, while the potential gradient at any given place is greatest in winter, the number of thunderstorms is most frequent in summer; and while the gradient in the lower layer of the atmosphere, at many places, usually is greatest from 8 to 10 o'clock, both morning and evening, and least at 2 to 3 o'clock p. m. and 3 to 4 o'clock a. m., no closely analagous relations hold for the thunderstorm. * * *

The chief conclusions drawn by Simpson from his observational data, and supported by numerous subsequent observations by other persons at widely separated places, are:

(*a*) That the charge on thunderstorm rain, amounting often to 5 to 10 electrostatic units per cubic centimeter, usually is positive.

(*b*) That, on the whole, the quantity of positive electricity brought down is more than three times greater than the negative.

While these observations were being secured a number of well-devised experiments were made to determine the electrical effects of each obvious process that takes place in the thunderstorm.

Freezing and thawing, air friction, and other things were tried, but none produced any electrification. Finally, on allowing drops of distilled water to fall through a vertical blast of air of sufficient strength to produce some spray, positive and important results were found, showing:

(1) That breaking of drops of water is accompanied by the production of both positive and negative ions.

(2) That three times as many negative ions as positive ions are released.

Now, a strong upward current of air is one of the most conspicuous features of the thunderstorm. Experiment also shows that raindrops of whatever size can not fall through air of normal density whose upward velocity is greater than about 8 meters per second, nor themselves fall with greater velocity through still air; that drops large enough—4.5 millimeters in diameter and up—if kept intact, to attain through the action of gravity a greater velocity than 8 meters per second with reference to the air, whether still or in motion, are so blown to pieces that the increased ratio of supporting area to total mass causes the resulting spray to be carried aloft, or, at least, left behind, together with, of course, all original smaller drops. * * * [The larger drops] fall as positively charged rain, because of the processes just explained. The negative electrons, in the meantime, are carried up into the higher portions of the cumulus, where they unite with the cloud particles and thereby facilitate their coalescence into negatively charged drops. Hence the heavy rain of a thunderstorm should be positively charged, as it almost always is, and the gentler portions negatively charged, which also very frequently is the case.

Such in brief is Doctor Simpson's theory of the origin of the electricity in thunderstorms, a theory that fully accounts for the facts of observation and in turn is itself abundantly supported by laboratory tests and imitative experiments.

* * * * *

The foregoing are only a selected few of the many recent contributions to the physics of the air, but they are sufficient, it is hoped, to show that meteorology is indeed a progressive branch of physics, and one eminently suitable to every type of scientific talent. The close observer, the clever experimentalist, and the keen analyst all can find in the phenomena of the atmosphere inexhaustible material and endless opportunities. But in science opportunity is only a synonym for duty, and of all words duty is the noblest.

SUBJECTS FOR RESEARCH IN METEOROLOGY.

It seems well at the present time for the Weather Bureau to take the lead in suggesting fundamental problems for research in meteorology—problems the solution of which, in part at least, may be undertaken by university post-graduate students in meteorology and by others who have opportunity for research. With this in view, the following subjects are proposed by the staff of the Central Office of the Weather Bureau.

Instruments and Observations.

1. Apparatus for recording the total radiation received from the sun and sky.

2. The measurement of the intensity of daylight.

A campaign to determine the intensity of daylight illumination in different latitudes under different atmospheric conditions is contemplated. Suitable apparatus for recording light intensities is highly desirable, but not yet available.

3. Methods of obtaining the directions and velocities of the winds at different elevations: (*a*) By direct observation with various forms of anemometers; (*b*) by observations of pilot and other balloons with one or two theodolites; (*c*) by observation of the movements of clouds by triangulation, or possibly by observations of the form, direction, and size of cloud waves.

4. Development of apparatus for determining soil temperature, soil moisture, and intensity of solar radiation as affecting plant growth.

Physical Properties of the Atmosphere.

5. Origin and maintenance of the outgoing current of negative electricity.

6. Source and effects of the penetrating radiation in the upper atmosphere.

7. The absorptive power of water vapor for long-wave-length radiation.

8. The absorption and radiation properties of the different constituents of the atmosphere.

Temperature.

9. A theoretical study of the cause of the altitude to latitude relation of the height of the stratosphere.

10. Diurnal variation in height and intensity of nocturnal inversions of temperature and their relation to "air drainage" and other phenomena.

This could be studied by means of frequent nocturnal soundings of the air in valleys with a small captive balloon carrying a meteorograph. Data of this kind will be of use in forecasting frost.

Atmospheric Pressure.

11. Reduction of surface pressures to those of stated levels in the free air.

Such reduced pressures would make possible the construction of fairly accurate weather maps for different levels. To obtain as nearly as possible the pressures aloft without direct observations at the required levels requires a close study of the vertical temperature gradient at each place, in order that for any type of weather at any time of day and season a proper temperature factor may be used in the hypsometric formula.

12. Diurnal temperature changes in the free air and their relation to the surface semidiurnal variations of pressure.

Winds.

13. Over- and under-running of differing winds, and attending phenomena.

14. Studies of atmospheric turbulence.

This may be done directly and indirectly in several ways: smoke movements, sound irregularities, irregular movements of balloons, internal movements in clouds, gustiness, cloud waves, temperature oscillations, temperature contrasts between neighboring fields.

Moisture.

15. Relation between meteorological factors and evaporation from soil and water surfaces.
16. The theory of evaporation.
17. Nucleation of the atmosphere. What is the nature of condensation nuclei, apart from ordinary dust.
18. Quantitative studies of fog, with respect to depth, density, water content, etc.
19. Cloud forms and their origin.
20. The cooling of the air by falling rain or snow, and atmospheric processes resulting from such cooling.

Cyclones and Anticyclones and Attendant Phenomena.

21. The origin, mechanism, and maintenance (1) of the tropical cyclone, (2) of the extratropical cyclone, and (3) of the migratory anticyclone.
22. The vertical extent of cyclones and anticyclones as rotary wind systems.
23. The connection (if such exists) between temporary changes in the general circulation of the atmosphere (if these can be localized and observed from day to day), and the development and movement of cyclones and anticyclones.
24. The connection between the temporary changes aloft from day to day at a given point or points, as determined by kite or balloon observations, and the development of cyclones and anticyclones.
25. Use of free-air winds, as measured by means of kites and balloons, in forecasting the movements of HIGHS and LOWS.
26. The temperature, wind direction, and velocity from the surface of the earth up to the greatest attainable altitudes (*a*) in the various portions of the extra-tropical migratory cyclone, (*b*) in the various portions of the "permanent lows," (*c*) in the different portions of the tropical cyclone, (*d*) in the different classes of anticyclones.
27. Cloud heights, directions, and velocities in different quadrants of HIGHS and LOWS, and their seasonal and latitudinal variations.
28. Horizontal and vertical distribution of temperature and humidity in different quadrants of HIGHS and LOWS and their significance in forecasting.
29. Temperature gradients in rainless cyclones compared with those of anticyclones.
30. Effects of differences in temperature upon wind velocities in and around cyclones.
31. The processes accompanying the origin, growth, and decay of thunderstorms.

Forecasting.

32. Weather maps at the 1,000 m. level as a basis for daily forecasts. (The sea-level maps now used show hypothetical, not actual, pressure distribution.)
33. An intensive study of cloud formations, movements, etc., with reference to their possible use in increasing the accuracy of weather forecasts.

This would probably involve primarily the question of cloud observations as an index to the development and direction of movement of cyclones and anticyclones. It is recognized that such studies may be of great value in forecasting in the western United States where phenomena of cyclones and anticyclones are not well defined. Particular attention should be given to formation and diurnal changes with reference to types of weather, and to certain forms, such as lenticular strato- or alto-cumulus, of frequent occurrence west of the Rockies.

34. Forecasting the occurrence of precipitation in a quantitative manner.
35. The relation between short and long interval changes in solar radiation and terrestrial weather.
36. Changes in atmospheric transmission in relation to world-wide changes of the weather.

For instance, changes resulting from volcanic dust veils.

37. Ocean temperatures in long-range forecasting. (See MONTHLY WEATHER REVIEW, Nov., 1918, 46: 510–512.)
38. Periodicity in climatic or weather changes; application of mathematics.

To what extent is harmonic analysis permissible?

Agricultural Meteorology.

39. Correlation of weather and crops.

Mathematical correlation of monthly mean temperature and total monthly precipitation with crop yield.

40. Effect of temperature, rainfall, and sunshine on plant development.

Intensive and direct comparison between weather factors and plant growth.

Other Applications of Meteorology.

41. Effect of sunshine on the melting of snow on (*a*) level ground; (*b*) slopes; (*c*) in forests.
42. Effect of the wind on the melting of snow.
43. Determination of temperatures injurious to perishable products in transit.

Climatology.

44. Distribution of rain and cloud through the day and night, and month by month, at various stations.
45. Neglected factors in climate.
46. The importance of evaporation in climatology.
47. Comparative climatology.

Classification of climates from various points of view, and especially a comparison of the climates of the United States with those of foreign countries.

48. City climates compared with those of the open country.
49. Climatic distribution of certain crops.

For example, there is a region along the California coast near Carmel where the weather conditions are eminently best for lima beans.

50. Physiological and psychological relations of climate and weather.

One topic under this head that has been conspicuously neglected is the susceptibility of certain individuals to the effects of thunderstorms ("astrophobia"). This and kindred topics are discussed in W. Hellpach's "Geophysiche Erscheinungen."

The subjects contained in this list have, in many cases, been investigated to a considerable extent already. They are mentioned here because the investigations have by no means given a full understanding of these matters. In view of the previous work which has been done, needless duplication of effort will be avoided if those who undertake to study these problems familiarize themselves with the whole existing body of knowledge in the particular branch of meteorology in which they intend to specialize. The results, also, when published, should be fully articulated with previous literature, either as extending, confirming, refuting, or otherwise modifying the same. A preponderant part of such literature is, as a rule, European, and much of it in foreign languages. The facilities of the Weather Bureau library, which contains the most extensive collection of meteorological literature in the United States, are available to those who ask.—C. F. B.

NOTES ON HURRICANES OF 1918.

By C. A. DONNEL, Meteorologist.

[Dated: Weather Bureau, Washington, D. C., Jan. 28, 1919.]

As in the preceding year, storms of tropical origin (so-called West Indian hurricanes) were fewer in number during 1918 than usual. One storm only attained characteristics entitling it to classification as a hurricane of the first rank in intensity. The paths of five disturbances, however, have been traced on Chart X of this issue of the MONTHLY WEATHER REVIEW.

Storm of August 1–6.—This was the most important tropical disturbance of the year. Five days after having been first noted near the island of Barbadoes it had crossed the Caribbean Sea and the Gulf of Mexico, reaching on the 6th the Gulf Coast of the United States about 30 miles east of the mouth of the Sabine River. In the REVIEW for August, 1918 (p. 379), appears a detailed account of this storm.

Storm of August 22–25.—First coming under observation in the vicinity of the Windward Islands on August 22, this storm during the succeeding 72 hours traversed a path only slightly north of due west across the central Caribbean Sea. On the 25th the disturbance reached the coast of British Honduras, whence it passed inland and probably dissipated. Like its immediate predecessor, this storm moved with great velocity for a tropical storm, the rate exceeding 15 miles an hour. It is reported that the S. S. *Mohegan* of the U. S. Aluminum Co., encountered this storm in latitude 14° 18′ north, longitude 66° 15′ west.

Storm of September 3–7.—The earliest report of the existence of this storm came from the Swedish S. S. *Texas* on September 3, the vessel then being some distance southeast of Bermuda, in latitude 25° 42′ north, longitude 59° 43′ west. Thence the storm advanced northwestward, passing to the west of Bermuda on the night of the 4th–5th. The storm recurved some distance out to sea from the coast of the United States, but crossed Nova Scotia on the night of the 6–7th, much diminished in intensity. The lowest reported pressure for this storm was 28.88 inches, at Hamilton, Bermuda, on the 4th.

Storm of September 9–14.—So far as is known, this disturbance did not attain violent character. It was first noted on the 9th near Barbadoes Island, and thence a track toward the northwest, across the eastern end of the Caribbean Sea, was taken. After crossing Haiti on the 12th, the path inclined to a more nearly northerly direction, and the storm at last disappeared on the 14th near the Great Abaco Island. In connection with this disturbance the Danish S. S. *Jungshoved* encountered a gale in latitude 23° 9′, longitude 27° 43′.

Storm of September 26–28.—The first evidences of this disturbance were present on September 26th in the extreme western portion of the Caribbean Sea, off the coast of British Honduras. On the morning of the 27th the storm was apparently in the Gulf of Mexico north of Yucatan. On the following day it had reached the northeastern Gulf, after having united with a disturbance from the interior of the United States. The storm did not progress farther than the Florida peninsula. In Pinellas County, Fla., and the near-by Gulf destructive winds occurred as a result of this storm, but no widespread damage was reported.

TROPICAL CYCLONE OF SEPTEMBER 14–17, 1918, IN THE PACIFIC OCEAN JUST WEST OF MEXICO.

By F. G. TINGLEY.

[Dated: Weather Bureau, Washington, D. C., Jan. 20, 1919.]

During the period from about September 14 to 17, 1918, a severe tropical storm prevailed in the Pacific Ocean immediately to the westward of the Mexican mainland. As there is comparatively little shipping in this part of the ocean, only a few reports have reached the Weather Bureau from vessels which felt the influence of the storm, but from other sources it is known that considerable loss was sustained by shipping and al o by various land interests at the extreme southern end of the Lower California Peninsula. Here the storm, having reached a land area, appears to have lost intensity.

According to a report which has reached the Bureau from Capt. E. Y. Hansen, of the Danish S. S. *Delagoa*, which encountered the storm, that vessel had an unusual experience. Running south in ballast along the west coast of Mexico, the influence of the storm was first felt on September 14, in about latitude 19° 00′ N., longitude 106° 00′ W. As the vessel and the storm center—the latter moving in a northwesterly direction—approached each other and the violence of the storm was felt more and more, the ship became increasingly difficult to steer and kept heading into the sea and practically toward the storm center. From 1 p. m. to 6 p. m. of September 15 it was necessary to keep the engine going astern to overcome the ship's tendency to follow the storm and not until the latter hour could the vessel be brought round and the course be resumed. The *Delagoa* is a ship of 3,541 gross tons. The report from Capt. Hansen is as follows:

September 14, 1918.—Increasing swell from ESE. During the afternoon reduced revolution, as propeller was jumping out of water. At midnight wind ENE., force 3; bar. 759 mm. (29.88 in.).

September 15, 1918.—Increasing strength of wind from NE. and high running sea from SE. At 4 a. m., bar. 753 mm. (29.65 in.); wind NNE., 10; sea SE., 10. Air very thick and rainy. Fog signal. On account of the different directions of wind and sea, the appearance of the air, and the ever falling glass, it was evident that a cyclone was approaching. At 5 a. m. endeavored to escape by steering SW., but as the ship was in ballast it proved impossible to steer her and she continued on a southerly course with the wind on the port quarter. (Latitude 19° 00′ N., longitude 106° 00′ W.) The wind blew from NNE. and at 6 a. m. reached the strength of a gale. The sea kept running high from the SE. At 8 a. m. the gale had increased to a violent hurricane accompanied by tremendous squalls and an exceptionally high and breaking sea. Bar. 736 mm. (28.98 in.), wind and sea 12. The ship was drifting southerly. She labored and was pitching and rolling fearfully and received terrific blows under the bottom.

The storm center passed close north and east of the ship at 10 a. m. The force of the gale was then at its highest. Bar. 732 mm. (28.82 in.). The wind now gradually shifted through N. and NW. to W. and, at about 1 p. m., to SW. The sea turned from SE. to E. and NE., at 5 p. m. first commencing to run with the gale from the SW. The hurricane continued with unabated strength till 4 p. m., then decreased to a strong gale from the SW. The ship kept heading the sea with the wind on the port quarter and by 11 a. m. was heading north. An attempt was made to get the stern through the wind by letting the engine go astern in order to come on a southeasterly course, and thus escape after the center had passed, but the ship refused to steer. From 1 p. m. the engine was kept going astern to enable us to increase the distance from the center, as the ship practically was heading right after it.

At 6 p. m. the ship came round and a south-southeasterly course was shaped.

The American S. S. *City of Para*, Capt. G. McKinnon, bound from Balboa to San Francisco, encountered the storm on September 16 while in latitude 22° 00′ N., longitude 110° 02′ W. The greatest force of the storm

was felt during the night of the 16th–17th, when the barometer fell to 29.35 inches and the wind attained a force of 9 from the west-northwest.

Following is the report from Mr. B. F. Yost, United States consul at Santa Rosalia, Lower California:

The greatest damage done at La Paz was to the shipping; every boat in the bay was blown upon the beach, all being more or less damaged and some totally wrecked. As La Paz is chiefly a maritime community, many people had all their savings invested in small sloops engaged in the coasting trade. Some of these vessels were totally destroyed, while others it has been impossible to repair thus far on account of the total absence of the necessary materials, such as oakum, copper sheets, and copper nails. The result is that most of the vessels are still on the beach waiting to be repaired before they can be refloated. The damages at La Paz and neighborhood will probably reach a total of 200,000 pesos. The N. and NE. winds did the greatest damage.

The American steamer *San Gabrien*, due at La Paz about that time, with a large general cargo, has failed to arrive and is reported lost, the crew having arrived at San Diego some days ago, according to newspaper accounts. Another American steamer, the *Coos Bay*, outward bound from San Francisco, is reported lost with all on board. Other vessels which had been reported lost are gradually being heard from.

Reports from San José del Cabo would indicate that the storm was extremely severe there. Small creeks became raging torrents, taking everything in their path and washing houses and trees into the sea. Many people lost their lives by drowning or by falling trees, the number of dead thus far accounted for being 25. San José being the center of the sugar-cane industry, that crop suffered considerable damage; other crops have suffered in proportion.

The communities of Santiago, Miraflores, and San Bartolomé were severely struck by the storm, although no deaths have been reported from those places. However, much damage was wrought to the growing crops. At Triunfo the storm was evidently less violent, but about 20 inches of rainfall is reported. Many houses were wrecked and most of

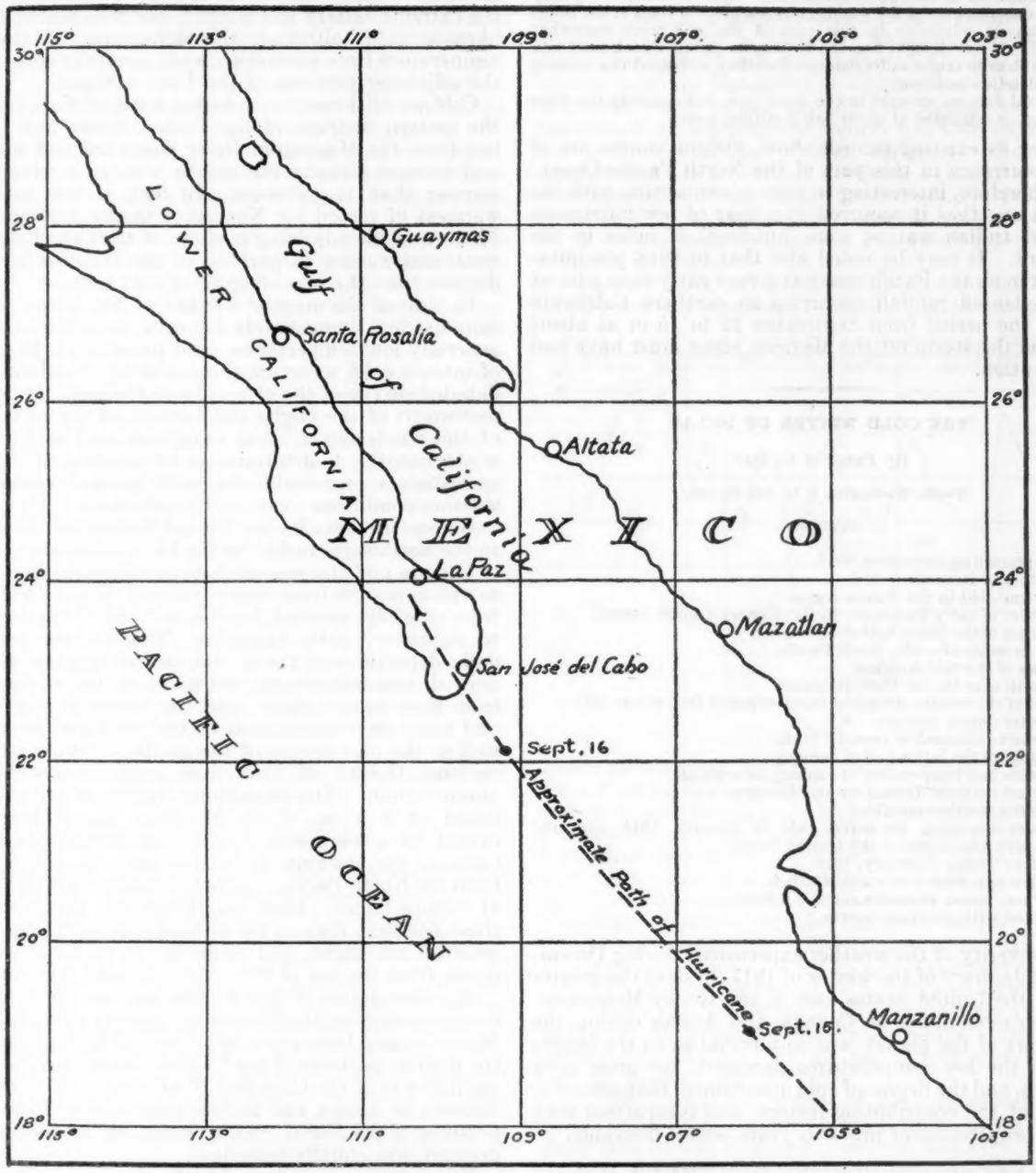

FIGURE 1.—Approximate path of tropical storm of September 14–17, 1918, North Pacific Ocean.

the roofs blown off. Nearly every building suffered more or less damage.

From all information obtainable the storm seems to have been confined to the southern part of the peninsula, being very serious in the San José del Cabo district, and probably reached some distance into the sea. It extended very little northeast or west of La Paz. The effects of the storm in Mazatlan, Altata, and Guyamas were not so noticeable, but a heavy southwest swell was felt. At Santa Rosalia very little wind was registered, and it never reached the velocity of a storm. A heavy southeast swell continued for two days without doing any material damage, except the washing out of a piece of track of the Boleo Co. Shipping schedules in this part of the gulf were somewhat deranged. It was thought that the 11 German sailing vessels anchored off Santa Rosalia might suffer damage, but they withstood the running sea in splendid condition.

The total damage wrought in the storm area, not counting the ships lost at sea, is estimated at about half a million pesos.

So far as existing records show, violent storms are of rare occurrence in this part of the North Pacific Ocean. It is, therefore, interesting to note in connection with the present one that it occurred in a year of few hurricanes in West Indian waters, some hundreds of miles to the eastward. It may be noted also that in 1918 precipitation set in on the Pacific coast at a very early date, almost unprecedented rainfall occurring in northern California during the period from September 12 to 15 or at about the time the storm off the Mexican coast must have had its inception.

THE COLD WINTER OF 1917–18.

By PRESTON C. DAY.

[Dated: Washington, D. C., Jan. 20, 1919.]

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Weather preceding December, 1917.
The weather of December, 1917.
- Extreme cold in the Yukon region.
- Weather of early December in the Eastern United States.
- Weather of the latter half of December.
- Low pressure over the North Pacific.
- Causes of the cold weather.
- Warmth over the far Western States.
- Some of the results attending the weather of December, 1917.

The weather during January, 1918.
- Extensive blizzard of January 11–12.
- Weather of the latter half of January.
- Pressure and temperature of January as a whole.
- Contrast between December and January.
- Is colder weather possible?
- Results attending the severe cold of January, 1918, over the eastern two-thirds of the United States.

The weather during February, 1918.
- Sudden appearance of warm weather.
- February mean pressures and temperatures.

Comparisons with previous records.

The severity of the weather experienced during December and January of the winter of 1917–18 over the greater part of the United States east of the Rocky Mountains, and also over much of Canada and Alaska during the early part of the period, was so unusual as to the length of time the low temperatures persisted, the great area involved, and the degree of cold maintained, that some discussion of the contributing factors, and comparison with similar occurrences of previous years, seems desirable.

WEATHER PRECEDING DECEMBER, 1917.

Reviewing somewhat the weather for a few months prior to December, 1917, we find that September was a cold month over much of the eastern half of the United States; but in Canada, particularly in the Northwest Provinces, the month was distinctly warm. October was a cold month in all portions of the United States from the Rocky Mountains eastward. In fact, it partook largely of the characteristics of a winter month in the great central valleys. Freezing weather occurred throughout nearly all portions of the country; the earliest frosts of record were reported from points in the Southwest: and unusually heavy snows occurred near the end of the month in the Lake region and northern Appalachian districts. (1), (4–7). Over the whole of Canada, except the extreme eastern and western portions, the month was likewise cold, although the departures of the mean temperature from normal were not generally so large as in the adjoining portions of the United States.

Cold weather continued during much of November over the eastern districts of the United States and Canada; but from the Mississippi River westward and in central and western Canada the month was, as a whole, much warmer than the average. In fact, it was among the warmest of record for November in the northern Great Plains and the adjoining portions of the Canadian Northwest, and warmer in portions of the Dakotas by several degrees than the preceding month of October.

In view of the marked warmth of November over certain districts, immediately following a month or more of generally low temperatures, and preceding a long period of intense cold, an unusual opportunity is afforded for a detailed survey of the atmospheric pressure, the resulting movement of the Highs and Lows, and the surface drift of the winds during that month as well as succeeding winter months, to determine an explanation of the causes immediately responsible for such marked variations in weather conditions over the United States.

Barometric data for the United States and the districts to the northward, including the far northwestern stations of Canada and the special stations maintained in Alaska, as well as reports from ships plying the North Pacific, have been carefully charted for the months November, 1917, to February, 1918, inclusive. These charts show the daily departures of the actual surface pressure from the normal, and indicate the deflection of the surface winds from their usual courses, and the locations of the larger and more permanent areas of high and low pressure, as well as the movements of the smaller cyclones and anticyclones thrown off from these great centers of atmospheric action. The departures shown on the charts are based on 8 a. m. (75th Meridian time) observations except for a few stations in the far northern districts of Canada, the stations in Alaska, and the vessel reports from the North Pacific, where the observations were made at various hours. However, during the winter season in these northern regions the normal diurnal fluctuations in pressure are slight, and probably no material error has arisen from the use of these data without correction.

An examination of these charts discloses the dominating factor controlling the November weather over the United States to have been a persistent area of high pressure over the interior portions of the United States, and the adjoining districts of the Canadian Northwest. Over the coast districts of Alaska and British Columbia and the nearby portions of the North Pacific Ocean, on the contrary, low pressure was equally persistent.

November is usually a month of considerable storm activity, particularly over regions adjacent to the higher latitudes of the North Pacific, and low-pressure areas frequently move off the ocean into the Pacific States or British Columbia, whence they pursue eastward or southeastward courses toward the Atlantic coast. Likewise high-pressure areas usually move into the Northwestern States from the British Provinces during the month.

It is a noteworthy fact that, associated with the ridge of high pressure over the northwestern States in November, 1917, not a single storm entered the United States directly from the Pacific. About the 18th, however, a deep depression from the North Pacific advanced into central Alaska and during the following few days it rapidly skirted the high-pressure area overlying the western Canadian Provinces, and entered the United States from the Hudson Bay region, appearing about the 21st as a severe storm over the Lake region, with a marked reduction in pressure over all eastern portions of the United States and Canada. This was followed by high pressure, and the first decided change to colder weather during the month over the eastern districts was inaugurated. To the westward, however, warm weather was maintained until near the close of the month, when a rapid disintegration of the dominating high area ended the stagnant condition that had persisted so long.

While the eastward drift of low-pressure areas from the North Pacific was apparently blocked, it was also unusual that not a single strong high-pressure area entered the western United States during the month. Such changes in pressure as appeared in the movements of the high areas over the United States were apparently developed from within, or reached the eastern districts by routes lying north of the Great Lakes; and it was not till the close of the month that this condition gave way. The final result of this long-standing area of high pressure was a more or less permanent reversal in the direction of the prevailing surface winds over the northwestern States and the adjacent portions of Canada, so that the usual frequent drift from the north was replaced by a general movement from the south that carried the warmth of the middle portions of the United States far to the northward.

CHARTS I to IV illustrate the persistence with which this general type of pressure distribution continued. Modifications of the general type occurred at intervals, but throughout the month the main features—high pressure over the United States, low pressure in northern regions, and the absence of well-marked cyclonic or anticyclonic movements—were dominant. This condition favored a more or less stagnant state of the atmosphere, clear skies, southerly winds over the central and northern districts, and high day temperatures.

THE WEATHER OF DECEMBER, 1917.

With the closing days of November there was a rapid fall in pressure over interior Alaska and the British Northwest, which quickly overspread the United States, and effectually dissipated the stagnant condition of high pressure that had existed so persistently during November. At the same time, pressure far above the normal, with intense cold, entered the Arctic portions of Alaska, and by the first of December the whole of that Territory, the adjacent portions of the North Pacific Ocean, and the greater part of British America as far east as Hudson Bay, were in the grip of one of the severest cold waves of recent years. High pressure and intense cold continued with slight intermissions throughout the entire month of December over the greater part of Alaska and the British Northwest. A few days after their first appearance these conditions had extended southward to the United States, where the month as a whole was one of the coldest of record over a large area east of the Rocky Mountains.

EXTREME COLD IN THE YUKON REGION.

Beginning on December 1, the temperature at Eagle, Alaska, fell to about −50° F. and later to −63° F., and during the entire month it did not rise above −25° F. The average of the daily maximum temperatures for the month was −40° F. and the average minimum was −52° F. Some conception of the degree of cold experienced in that territory during this period is afforded by comparing the monthly mean temperature of December, 1917, at Eagle, with the means for the same month of other years. The mean temperature for December, 1917, was −46° F.; the lowest previous mean for the same month, in a more or less complete record covering the past 30 years, is −23° F. December, 1917, therefore, averaged 23 degrees F. per day colder than the coldest previous December of which there is record. It is probably safe to say that no such depression in temperature from previous low records has been experienced in the known history of that Territory. The normal temperature for December at Eagle is about −12° F.; the depression of the mean for December, 1917, below the normal for the month was therefore about 34 degrees F., a record which, likewise, has probably not been exceeded in Alaska.

At Fort Yukon, on the Arctic Circle, near the international boundary between Alaska and Canada, the average

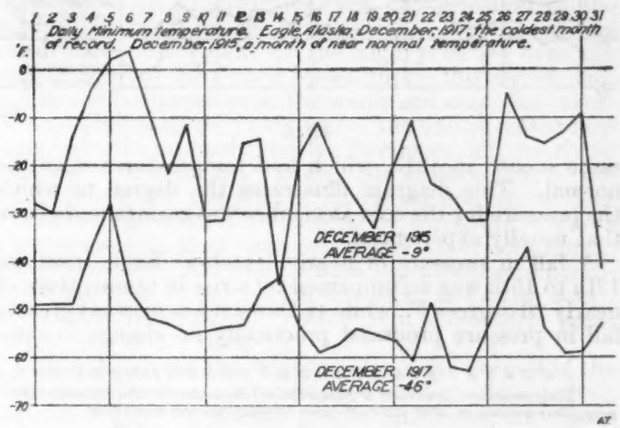

FIG. 1.

minimum temperature was −58° F., about 6 degrees F. lower than at Eagle. The lowest recorded was −67° F., and on no day during the whole month did the minimum temperature rise above −45° F. A note on the report from that station reads as follows, "White men who have been years in the country, and Indians, say they have never known such continued cold weather."

At Dawson, in the British Yukon, the month was by far the coldest ever known. The average of the daily maximum temperatures was −49° F., and of the daily minimum −54° F.; the monthly mean, −51° F., was 29 degrees F. lower than the lowest mean of any previous December and nearly 40 degrees F. below the average. The highest temperature observed during the month was −40° F. and the lowest −63° F.

The persistence and degree of the cold experienced in those far northern regions during December, 1917, is well illustrated by the diagrams herewith (see Figs. 1 and 2) showing the daily fluctuations in the minimum temperature at a few points for that month as compared with a month having about the normal temperature. Figures 1 and 2 show the daily fluctuations of the minimum temperature at Eagle and Dawson for December, 1917, as compared with like records for years having about the normal temperature. Similar values for Fort Yukon, Alaska, December, 1917, are also shown on Figure 2.

At Eagle, the month, while cold throughout, nevertheless, had periods of somewhat moderate temperature,

as shown by the diagram, the range for the month being about 40 degrees, the temperatures fluctuating with the rise and fall in pressure. At Dawson, however, the cold was persistent, the range for the month being only slightly more than one-half that at Eagle.

Figure 3 shows the daily fluctuations of the atmospheric pressure at Eagle for December, 1917, and for the

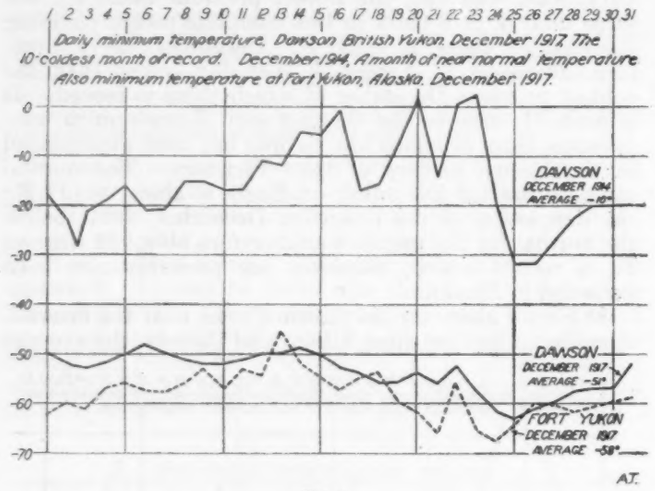
Daily minimum temperature, Dawson British Yukon, December 1917, The coldest month of record. December 1914, A month of near normal temperature
Also minimum temperature at Fort Yukon, Alaska, December, 1917.
DAWSON DECEMBER 1914 AVERAGE -15°
DAWSON DECEMBER 1917 AVERAGE -5°
FORT YUKON DECEMBER 1917 AVERAGE -58°
AT.

FIG. 2.

same month in 1915, which had temperatures near the normal. This diagram illustrates the degree to which the pressure for the cold December was maintained above that usually experienced.

A fall in pressure of nearly 1 inch at Eagle from the 12th to 15th was accompanied by a rise in temperature of nearly 20 degrees F., while at Dawson a somewhat greater fall in pressure produced practically no change in tem-

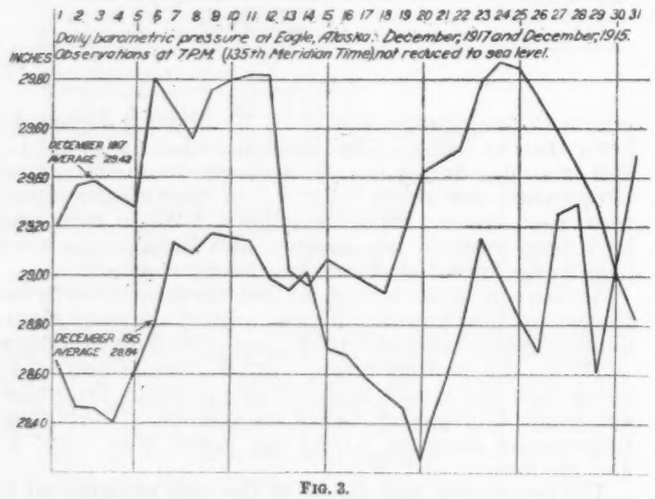
Daily barometric pressure at Eagle, Alaska: December, 1917 and December, 1915.
Observations at 7 P.M. (135th Meridian Time), not reduced to sea level.
INCHES
DECEMBER 1917 AVERAGE 29.42
DECEMBER 1915 AVERAGE 28.84

FIG. 3.

perature. At Eagle, however, there was a change in the direction of the wind from northwest to southeast during the period, whereas at Dawson no change in the direction was observed.

While the persistence of the low temperature at Dawson despite marked changes in pressure is somewhat unusual, the general correctness of the record is fully established by the similar report from Fort Yukon, as is shown in Figure 2.[1]

[1] Apparently the cold air in the upper Yukon Valley could not be moved by the changes in winds which undoubtedly occurred in the warmer air a slight distance above the surface.—*C. F. B.*

WEATHER OF EARLY DECEMBER IN THE EASTERN UNITED STATES.

The high-pressure condition was particularly pronounced during the period December 3 to 13 from Alaska south to the western districts of the United States, extending later into the eastern and southeastern districts, where high pressure continued until about the 20th, and again from about the 21st to near the end of the month. The extent of these great high-pressure areas is well illustrated by the accompanying charts, which show their distribution on several dates and combinations of dates during the above periods. (See CHARTS V–X, and XII.)

From this great area of high barometric pressure with its phenomenally low temperature, there broke off a series of anticyclones that moved southeastward over the British Northwest and into the United States. CHART V, December 5, shows the first great southward projection of the high pressure that had been developing in Alaska since the beginning of the month. At this time, the temperature had fallen to nearly −20° F. in North Dakota. However, the general warmth previously existing, and the absence of any snow-cover, so modified the cold of this anticyclone that over most of the country east of the Rockies the temperatures were reduced only to near the normal for the season. In the Rocky Mountain region it is apparent that while the pressure had risen, the cold air moving southward near the mountains was confined to the lower levels and did not extend to the higher elevations of the mountains, although farther east, over the Plains region, the upper air observations indicate that it did extend to rather high altitudes. (2).

About the 7th, a strong high pressure area moved southeastward in the wake of a heavy snowstorm, bringing during the following few days the coldest weather of the season to date into the Gulf and south Atlantic States. The southward movement of the cold air accompanying this high area was greatly augmented by the presence of an area of low pressure over the Gulf States at the same time.

CHART VI, December 10, shows a further development of high pressure over the northern districts and a marked projection of it into the southern portions of the United States. This distribution clearly illustrates the penetration of the cold northerly winds into the Great Plains and Mississippi Valley. The line of zero temperature at that time extended into Oklahoma and east to the Appalachians.

By the 12th, before temperatures in the West had approached normal conditions again, a new southward extension of the great northern anticyclone became apparent along the northern borders of the United States, and temperatures in North Dakota and Montana fell to −20° F. or lower. This cold wave advanced rapidly into the central valleys and temperatures from −20° F. to −30° F, were experienced as far south as Iowa and Nebraska. Immediately in front of this high area severe storm conditions developed, and during the 13th and 14th heavy snow with high winds prevailed from the Lake region to New England, followed by marked cold within the succeeding few days, the temperature falling to nearly −30° F. in portions of New England.

While these adverse weather conditions were being experienced in the East, a great barometric depression was forming in the North Pacific west of British Columbia and southern Alaska. During the 14th and 15th (see CHART VII, Dec. 15), this depression increased greatly in magnitude, and gradually extended inland over the British Northwest as far eastward as Hudson Bay; but high pressure to eastward seems to have blocked effectively its further progress, and it gradually dissipated.

Conditions were still favorable for continued cold northerly winds in the Eastern States and the Maritime Provinces, but southerly winds had set in from the Mississippi River westward and in portions of the Canadian Northwest. Temperatures in the cold western districts of the United States responded promptly to the change in air movement, particularly in the Missouri Valley and the adjacent portions of Canada, where the rise about the 15th–16th amounted to 20 to 40 degrees F. within 24 hours. With the type of pressure distribution indicated by CHART VII, a period of more moderate temperatures prevailed in the central districts of the United States, continuing till about the end of the second decade, when high pressure again became dominant in the far north.

WEATHER OF THE LATTER HALF OF DECEMBER.

High pressure and severe cold still continued over northern Alaska and the Behring Sea region, and gradually moved southeastward during the closing days of the second decade, so that at the beginning of the third decade of the month high pressure had again become firmly fixed over Alaska, the British Northwest, and the adjacent portions of the North Pacific, and a second period of extreme cold, somewhat more intense than the first, had set in over those districts. By the 24th the pressure had risen to more than 1 inch above normal at points in Alaska; and the southern extension of the high area had advanced into the northern portions of the United States between the Great Lakes and the Rocky Mountains with temperature falls approximating 50° F. An eastward moving barometric depression extending from Texas to the Great Lakes accompanied the rapid southward advance of the high pressure area; and by the morning of the 25th nearly the whole of the North American continent was under unusually high pressure. CHART VIII, December 25, illustrates the reestablishment of the pressure type prevalent during the first half of the month, as indicated by CHART VI, previously discussed. A marked fall in temperature had occurred over the northern districts of the United States and during the following day the cold extended to the Gulf and Atlantic coast districts. At Eagle, Alaska, the pressure had remained about 1 inch above normal, but the center of the high area gradually drifted southward, and during the 28th and 29th entered the northern portions of the United States between the Great Lakes and the Rocky Mountains, with barometer readings, reduced to sea level, above 31 inches, about 1 inch above the normal. At this time, temperatures ranged from −62° F., on the Arctic Circle in Alaska, to −30° F., or lower, in portions of Iowa and Nebraska, and to freezing on the south Texas coast. This cold wave extended to the eastern portions of the United States and Canada during the following few days, the temperature falling below −40° F. in the heavily snow-covered northern portions of New York and New England, and to freezing in the central portions of the Florida Peninsula. This was one of the severest cold waves of record over the northern portions of the country from the Great Lakes eastward, particularly in New England.

LOW PRESSURE OVER THE NORTH PACIFIC.

While the air pressure over Alaska, western Canada, and most of the United States was far above normal during the last decade of the month, the pressure over the North Pacific, as shown by a few vessel reports from that region, was persistently below normal. The center of the low area seemed to oscillate from day to day; about the 25th, the cyclone covered a wide area with the lowest barometer readings west of California. The depression moved slowly northward, and near the close of the month had increased greatly in magnitude, and apparently covered the entire North Pacific, with the center off the Alaskan coast, where the pressure was more than 1 inch below normal. (See CHART IX, Dec. 31.) The influence of this low area extended into the interior of Alaska, and at the end of the month pressure in that Territory had very generally fallen to about normal, warmer weather had set in, and the period of unprecedented cold that had persisted for a month or more over Alaska and the adjoining portions of the Canadian Northwest, with scarcely an appreciable break, came to an end temporarily, although farther south over Canada and in the eastern two-thirds of the United States, where a heavy snow-cover had been established, cold weather continued.

CAUSES OF THE COLD WEATHER.

CHART X shows the average departure of the surface pressure from the normal during the 10-day period, December 3 to 12, inclusive, and the direction of the dominating winds for the same period. A glance at this chart shows the extent of the high pressure over the regions north of the United States during this period, and, due to the low pressure in the south and east, the favorable conditions thereby created for the unobstructed flow of air from the intensely cold far Northwest into nearly all portions of the United States. An examination of the wind records for the period, in the regions where their true directions were not obscured by topography, shows how persistently they were maintained from cold northerly regions. In the Great Plains the winds were northerly from 40 to 70 per cent of the time, and as far south as San Antonio, Tex., they were from a northerly point 60 per cent of the time.

CHART XI shows the departure from the normal of the average daily mean temperature for the same period, December 3 to 12, inclusive, and illustrates the extent to which the temperature was influenced by the high pressure and the resultant northerly winds.

CHARTS XII and XIII show respectively the departures of the surface values of pressure and temperature from the normal, and CHART XII shows also the direction of the prevailing winds for the entire month of December.

These charts indicate that practically the whole of the North American continent was under the influence of a great area of high barometric pressure with corresponding cold, central north of the Arctic Circle, which doubtless extended into other northern regions, although lack of reports at this time precludes any conclusions as to the extent of the cold area. Particular attention is invited to the direction of the winds as disclosed on CHART XII, which explains at once why cold was so persistent east of the Rocky Mountains and warmth equally so to the west.

Another factor in the cold weather—one not so evident in December as in January—was the unusually extensive and deep snow cover over a large part of the eastern United States during most of the month.(5) This snow surface by favoring rapid cooling of the air at night [2] and

[2] The snow surface at night cools quickly to a low temperature, because it is a good radiator, and is well insulated from the relatively warm ground by the low conductivity of the snow. The radient energy emitted from the cold surface is much smaller than that from the surface of the bare ground, which under the same atmospheric conditions is always warmer. Prof. W. J. Humphreys has shown (orally) recently that the air above the snow is cooled rapidly not only conduction, and some radiation, to the cold snow surface, but also by the radiation to space. This net radiation space is usually almost balanced by that received from the ground and warmer strata of the atmosphere; but with very little radiation from below, the air some distance above the snow surface is allowed to cool appreciably.—*C. F. B.*

by preventing appreciable heating by day,[3] kept the northerly winds cold. Also, on account of the large amount of heat required to melt the snow, the infrequent southerly winds could not maintain their high temperatures. Figure 4 [4] shows how the extremely cold weather at Cincinnati was associated with a great depth of snow on the ground.

Temperatures as low or lower, and barometric pressures as high, have doubtless existed in the past history of these far northern regions, but no known record appears of their continuation over such a long period as in December, 1917.

Why these abnormalities existed so persistently at this particular time is not disclosed by any terrestrial or solar observations now available, except, perhaps, those of

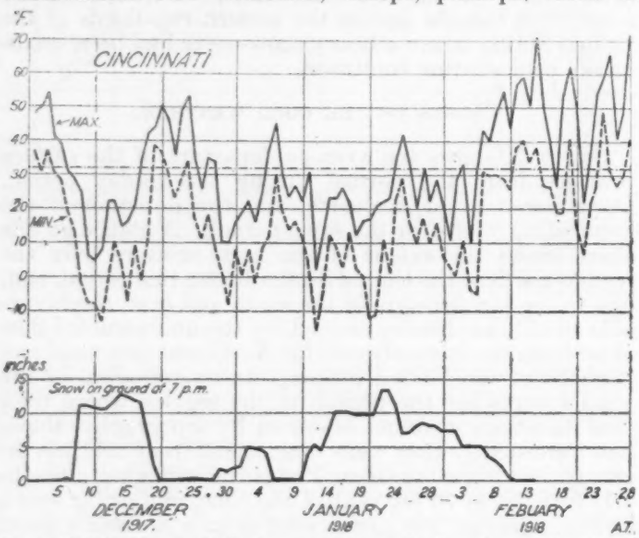

FIG. 4.—Relation between depth of snow on the ground and maximum and minimum air temperatures at the Weather Bureau Station in Cincinnati, Ohio.

sunspot numbers. Prof. H. H. Kimball, in his usual report on solar and sky radiation, in the WEATHER REVIEW of December, 1917, indicates that no appreciable departure from the normal was apparent in the solar output of heat; in fact, at the most northerly station at which such observations were made, Madison, Wis., there was an apparent slight excess of heat received from the sun as compared with the normal. This, however, is accounted for, in part at least, by the unusual dryness of the atmosphere, which favored increased transmission of the solar energy through it.[5]

Observations of the upper air strata, as obtained at the Drexel, Nebr., aerological station, do not show more than the normal reduction in temperature with increasing altitude. In fact, during December there was a decided lack of the usual decrease in temperature with elevations above 5,000 feet, the upper levels having slightly higher temperatures than for preceding years. During January, 1918, however, there was evidence that these portions of the atmosphere were markedly colder than usual. A report on the upper air condition during the winter under consideration will be found in Supplement No. 12, MONTHLY WEATHER REVIEW, issued October 26, 1918.

WARMTH OVER THE FAR WESTERN STATES.

No summary of the weather of December, 1917, would be complete without some reference to the abnormal warmth over the States west of the Rocky Mountains, which was as persistent as the cold to the East.

Noting the movements of the highs and lows for December, 1917, as shown by CHARTS II and III in the MONTHLY WEATHER REVIEW for that month, it is seen that no anticyclone entered the northwestern States directly from the Pacific during the month. In fact, of the nine distinct offshoots from the great high-pressure area lying close to the Arctic Circle, practically all entered the United States east of the Missouri River and none pursued the usually frequent course southeastward over the eastern slopes of the Rocky Mountains. As a result of this more easterly advent of the high areas into the States, the accompanying cold winds lost much of their force before reaching the mountains to the westward and did not pass the barriers presented by the high ranges. The districts to the westward therefore continued under the influence of the westerly winds blowing off the comparatively warm waters of the Pacific.

This is well illustrated on CHART X, which shows the prevailing direction of the surface winds during the 10-day period, December 3 to 12 inclusive, and also on CHART XII, showing the prevailing direction of the winds for the entire month. On the plains of Washington and Oregon and over an area extending southward and eastward, the surface wind resultants had strong westerly components. In the higher altitudes these westerly winds were still dominant, as shown by the stations near the Rocky Mountain Divide, and by the records of the upper air observations at Drexel, Nebr., on the Great Plains farther east, where at elevations between 3,000 and 9,000 feet the temperatures were distinctly higher than at the surface.

In addition to the failure of the high areas to influence materially the course of the winds over the districts west of the mountains, an unusually large number of moderate low pressure areas entered British Columbia from the Pacific and remained north of the United States until after crossing the mountains. This favored southerly winds over the far Northwestern States, thereby adding further to the sources of warmth for that region.

[3] Dr. C. G. Abbot with his pyranometer has found that a new snow surface reflects 70 per cent of the incident solar and sky radiation, Proc. Nat. Acad. Sci., 1916, 2, p. 335. The remainder can not, of course, raise the temperature of the snow surface above freezing.—*C. F. B.*

[4] Plotted and inserted by C. F. Brooks.

[5] Since these measurements have not been corrected for atmospheric absorption, they are representative only of the intensity of radiation at the earth's surface and could not be expected to give quantitative values of the variations in the solar heat received at the outer limits of the atmosphere. Daily pyrheliometric observations to determine the solar constant were not made, the Smithsonian Institution's solar station not then having been established in Chile. (Cf. Proc. Nat. Acad. Sci., 1918, vol. IV, pt. 8. Reprint, Sci. Am. Suppl., 2241, Dec. 14, 1918, p. 384. Abstract, Science, Dec. 27, 1918, N. S. 48: 635-636. M. W. R., Jan., 1919.) Those observations which were made during 1917, however, Dr. C. G. Abbot says, had a very high average. This is what we would expect, for 1917 seems to have been the year of maximum sunspots in the 11-year cycle.

The 11-year sunspot cycle is a cycle in solar activity, during which the sun radiates the most heat when the spots are most numerous. (Cf. C. G. Abbot: The sun and the weather, Scientific Monthly, 1917, 5: 400-410). Indirectly, then, sunspot relative numbers may be used to obtain approximately the variations in the sun's heat emission. The Wolfer provisional sunspot relative numbers for 1917 and the first half of 1918 are as follows (MONTHLY WEATHER REVIEW, 1918, 46: 403, & Terr. Mag., Mar., 1919):

	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1917.....	76.2	71.8	86.6	63.7	112.7	113.8	117.0	143.2	121.9	71.4	90.1	116.8
1918.....	96.3	83.4	72.2	76.5	76.5	64.8	.....	.....	.....	.....	.....	.....

To find a maximum of greater intensity than that of May, 1917, to January, 1918, it is necessary to revert to 1871. Since 1749 there seem to have been only eight Decembers with more sunspots than in December, 1917: 1777, 1787, 1788, 1789, 1836, 1837, 1848, and 1870.

For some reason the earth in general is colder when the sun is sending us more heat than when it is radiating less (cf. W. J. Humphreys, Physics of the Air, Journ. Franklin Institute, Sept. 1917, pp. 406-408). At any rate, as we should expect, the atmospheric circulation is most energetic when the earth is receiving the most energy. Changes in the strength of the atmospheric circulation necessarily go hand in hand with changes in the steepness of the barometric gradients. In other words, the great high pressure areas are higher than usual and the low pressure areas lower than usual in times like the winter of 1917-18, when the sun was hotter than usual. Cf. H. Arctowski: Variations in the distribution of atmospheric pressure in North America, Bull. Am. Geogr. Soc., 1910, 42: 270-282.) The general character of the weather at any place seems to be closely dependent on the positions and intensities of the neighboring "centers of action" whose changes seem to be more directly associated with solar changes than is the weather. This is apparently as far as we can go at present. If, as we can not, we could say that the same intensity of sunspot maximum would produce the same features of pressure *distribution*, similar cold winters should have been experienced in the years enumerated. The Decembers of these years were not all cold ones, nor are all unusually cold Decembers included.—*C. F. B.*

SOME OF THE RESULTS ATTENDING THE WEATHER OF DECEMBER, 1917.

At the beginning of December the ground was practically bare of snow over the entire country, as little had fallen during the preceding month, and the heavy snows of the latter part of October had disappeared. On the first two days of December, however, there was considerable snow in northern New York and New England. During the following week heavy snow fell in the Ohio and middle Mississippi Valleys with lighter falls over nearly all northern districts, and by the end of the first decade all central and northern districts from the Rocky Mountains eastward were snow covered, the amounts being especially heavy from Arkansas northeastward to western Pennsylvania. During the following week considerable snow occurred over the Appalachian Mountains and to the eastward and northeastward; and the depth over northern New York and the interior of New England had increased to 2 feet or more.

During the latter part of the second, and the early part of the third, decade of the month there was a general reaction towards higher temperatures, and the large body of snow over the Ohio Valley and adjacent regions disappeared. (see Fig. 4, for example.) There was little snow during the last week of the month, but at its close a rather extensive storm area was central in the Ohio Valley, moving southeastward. During the first day or two of January, 1918, it passed to the Atlantic coast region, leaving a moderate covering of snow from the Carolinas northwestward to the northern Rocky Mountain district.

The heavy snow covering during much of the early part of the month, particularly east of the Mississippi River, where in many districts the fall for the month was in excess of that usually received during the entire year, greatly interfered with farming operations. Plowing was abruptly halted, and the husking of corn proceeded so slowly that at the close of the month a large part of the crop was still in the fields. Heavy snow and extreme cold in the principal coal-mining districts of the east interfered seriously with the production, transportation, and distribution of fuel. At the close of the month much suffering from the severe cold was being experienced, and many important industries were either partially or wholly suspending operations from lack of coal. Heavy ice had formed on most of the important northern rivers, and in the Ohio the conditions were reported as the worst in its history, gorges forming which held for many weeks. (3), (5). While the heavy snow-covering afforded ample protection to winter wheat over most districts during the colder periods of the month, much damage from the severe cold was experienced by the truck crops of the South.

To the westward of the Rocky Mountains and even in a strip just east of the Rockies the mild weather favored all outdoor occupations. Pastures continued green and winter grains made unusual growth. The ground remained unfrozen much of the time, and plowing proceeded without material interruption. In the southern and more western portions of this district the month was abnormally dry. Practically no snow fell during the month, and as November had also been dry the mountains were, in the main, free of snow. This was particularly the case in the Sierra of California, where at the end of the month the deficiency of the snow cover was the greatest ever known, and the possibilities of the failure of the usual water supply were becoming alarming.

THE WEATHER DURING JANUARY, 1918.

With the close of December there was a complete change in the pressure distribution over the districts north of the United States, which ordinarily might have been interpreted as indicating a break in the cold that had persisted so continuously during the preceding month over the central and eastern States. The strong high area that had been maintained during December over the far north had now largely dissipated, and temperatures in Alaska and the British Northwest promptly rose to normal or higher. The change in temperature at Eagle, Alaska, was from −59° F. on December 30 to +7° F. on January 4, a rise of 66° F. The fall in pressure during nearly the same period amounted to an inch or more.[6]

In the United States, however, no such changes were experienced. The remnant of the high-pressure area that had drifted from the far north was moving southeastward near Hudson Bay, and cold northerly winds still swept the eastern districts, temperatures below −30° F. being reported from northern New England.

In the Middle West the first few days of January showed some moderation in temperature, due to southerly winds induced by diminishing pressure in the western Canadian Provinces, which at times were under the influence of a great area of low pressure that covered the whole of the north Pacific Ocean, a condition favorable also for the continuation of unseasonably warm weather in the districts west of the Rocky Mountains.

By the middle of the first decade low pressure had extended to practically all central, eastern, and southern portions of the United States, and there was a general warming up, although the increase in temperature was not in proportion to that usually experienced with such a marked fall in pressure. The snow cover which came with the closing days of December and the beginning of January extended over a wide area as far southward as Tennessee and the Carolinas, and doubtless contributed more than bare ground would have done to the maintenance of low temperatures. Moreover, on account of the unusually low pressure over the southern districts of the United States, such strong gradients were set up as to cause a pronounced flow of cold air from the north into the central and southern portions of the country.

EXTENSIVE BLIZZARD OF JANUARY 11–12.

A further increase in the depth of the snow cover occurred during the 6th to 8th, the fall in the vicinity of Lake Michigan being particularly heavy. At the same time, moderately high pressure with attendant cold weather had again developed over Alaska, the British Northwest, and the North Pacific. Tnis gradually extended into the United States by way of the Rocky Mountains, and brought to portions of that and adjacent regions the coldest weather of the season so far. The movement of this high area southward was greatly augmented by the sudden development near the middle Gulf coast of an extensive low area, which advanced rapidly toward the Lake region, accompanied by rain, sleet, or snow over nearly all districts from the Mississippi River eastward, the snowfall being particularly heavy in the Ohio Valley and portions of the Lake region. The greater portion of the country was now

[6] Without any change of pressure at an elevation of about one mile, such a change 3–4 per cent in the pressure at the surface, could result from a 15–18 per cent change of density (due to a 60–70° rise from such a low temperature) in approximately the first mile of atmosphere above the earth's surface.—*C. F. B.*

under a blanket of snow, the cover east of the Mississippi River being unusually deep. With the movement of the center of low pressure to the Lake region during the 11th and 12th, and the advance of the high into the Mississippi Valley, strong pressure gradients were established and northwest to southwest gales prevailed from the Great Plains to the Appalachian Mountains. Although the pressure at this time had fallen rapidly in northern districts, and was below normal over nearly all parts of the United States, and northward as far as observations extended save over a small area in central Canada, the unusually low pressure attending the storm that moved from the lower Mississippi Valley to the Lakes greatly favored the movement of cold air from the north into the Central Valleys. During the 11th and 12th very strong, cold, north to southwest winds prevailed over the middle portions of the United States, carrying the temperature to nearly −20°F. as far south as Tennessee, and to 20°F. or lower on the Gulf coast and in Northern Florida. (See CHART XIV, Jan. 12.) In the Ohio Valley and adjoining regions January 12 was probably the coldest and most disagreeable day experienced in a century. Southwesterly high winds to strong gales piled the deep snow into huge drifts that seriously blocked traffic, and the extreme cold added greatly to the discomfort of the people already suffering severely from lack of sufficient fuel to meet the requirements of normal winter weather.

Summing up the general weather conditions in Ohio for January 12, Mr. W. H. Alexander, at Columbus, the official in charge of the Weather Bureau climatological work in Ohio, states:

> Unfortunately in this case, as in many others, there are some weather characteristics resulting from the combination of meteorological factors that are not revealed by a mere statement of these factors or elements. For instance, it is scarcely possible to portray adequately the real penetrating character of the winds that blew with gale force all day, causing great suffering and even death to man and beast. It is true that at some stations the temperature has been lower on previous occasions than during this storm; at some the snowfall has been heavier on other occasions; and even higher winds velocities have been recorded, but rarely if ever has there been in this State a combination into which the principal weather elements entered with such force and persistency as during the cold wave of January 12, 1918.

The severe cold attending the blizzard on the 12th drifted east and was followed by a quick but temporary return to normal winter weather. At this time the barometer was below normal over practically the entire North American continent and the adjacent waters of the North Pacific Ocean, and another cyclone was developing in the Gulf region. Within a few days the flow of cold air from the north was again in operation and temperatures east of the Rocky Mountains became once more far below the seasonal average, except in the South.

By the middle of the month the cyclone referred to above had developed and moved to the Atlantic coast, causing heavy snows from central Arkansas and northern Oklahoma northeastward over the middle Mississippi Valley, the northern watershed of the Ohio, and portions of the Lakes region. Unusually deep snow now covered practically the entire central and northern districts from the Plains region eastward. About the middle of the month pressure above the normal overspread Alaska and the adjacent districts, moving within the next few days to the southeastward and further reenforcing the cold already existing throughout the eastern United States.

WEATHER OF LATTER HALF OF JANUARY.

With little modification, the pressure continued slightly above normal from the middle to the end of the second decade over the central districts of the United States; and as far north as observations extended, the center of the greatest departure above the normal appeared along the south Alaska coast and over the nearby waters of the North Pacific. There was a diminution of pressure to the south and east and well-developed lows appeared in the west Gulf region and east of the Great Lakes about the 19th. (See CHART XV, Jan. 19.) Although pressure considerably above normal now existed in nearly all districts north of the United States, no unusual cold was being experienced in those regions; in fact, for a week or more preceding that time the temperatures at Eagle, Alaska, had been but slightly below zero (F.). Farther southeast in the Great Plains region of western Canada, Medicine Hat had temperature about normal, but in the United States temperatures in the upper Mississippi Valley were near 25 degrees (F.) to 30 degrees (F.) below normal.

About the 20th low pressure suddenly developed in central Alaska, and during the following few days extended southeastward over western Canada, and by the 23d the center had apparently entered the United States, at which time pressure was low over the entire central and northern districts west to the Rocky Mountains and north over nearly the whole of Canada and Alaska. Despite the low pressure in the eastern districts of the United States, unusually cold weather continued, but in the near Northwest warmer weather was experienced for a few days, the decreasing pressure along the northern boundary inducing southerly winds. During this period high pressure was again developing in the North Pacific, and by the middle of the last decade it had become established over Alaska and western Canada, where the severest cold since December was being experienced, the temperature about this time at Eagle and Dawson going to −50° F.

This cold wave was only of short duration in these far northern districts, but as it extended southward into the United States it brought, in some districts, the severest weather of the winter. The cold continued over much of the country east of the Rocky Mountains until the end of the month. CHART XVI, January 30, again illustrates the opportunity for easy movement of cold air from northern regions into the Central and Southern States. High pressure was now advancing from the interior of western Canada, where temperatures of from −30° to −50° F. were being experienced. At the same time, pressure was again low over the Gulf and southwestern districts, and cold, northerly winds, having initial temperatures far below zero, were advancing into the interior valleys. Here again, low pressure in the Gulf region favored the swift movement of cold air into the interior and Southern States, with little opportunity for heating, due to the expanse of the snow and ice covered areas over which it passed. Temperatures fell to −20° F. in Nebraska and to freezing in southern Texas. With pressure below normal in the Southwest, the way opened, likewise, for the movement of cold air into regions west of the Rocky Mountains; and the first severe cold of the winter prevailed in the far northwestern States at the close of the month.

Considering the period from about January 7 to 23, inclusive, 17 days, during which time temperatures in the east-central portions of the United States were almost continuously below normal, it is of interest to note that in the far north this period was very generally warmer than usual. At Eagle, Alaska, the average temperature from January 7 to 23 was above the normal continuously, except on two days, and the mean temperature for the period of 17 days, −6°F., averaged nearly 10 degrees (F.) above the normal. At Louis-

ville, Ky., a point nearly 2,000 miles farther south, the temperature was below the normal during the entire period, and on no day was it less than 10 degrees (F.) below; and the mean for the period, 15°F., averaged 20 degrees (F.) below normal. The only apparent explanation of this condition lies in the fact that the distribution of the pressure was such as to afford easy movement of cold air from northerly regions into the middle and southern portions of the United States without the usual gain of heat. This was made possible (1) partly because of the great blanket of snow over which these winds blew, thus maintaining to more than the usual extent, or even augmenting, the initial cold of their origin by affording opportunity for more intense cooling by radiation by night and for lack of heating due to the reflection of the sun's heat by day, and doubtless (2) partly due to the fact that the temperature of the upper layers of the atmosphere had become unusually low as a result of the long period of cold over the northern districts during the preceding month.

PRESSURE AND TEMPERATURE OF JANUARY AS A WHOLE.

In examining the daily charts showing the distribution of atmospheric pressure during January, 1918, over the United States and Canada so far as revealed by the observations at hand, two pronounced features are observed. First, the absence of areas of marked high pressure over northern districts, considering the unusual cold experienced in the central and eastern portions of the United States, and second, the far southerly courses pursued by both the HIGHS and LOWS in their movements across the country.

CHART XIX shows the departures of the surface air pressure for the entire month of January from the normal and the prevailing course of the winds. Examining this chart, it is seen that while pressure was only slightly above normal in the far northern districts, it was decidedly low to the southward and eastward, a condition already pointed out as favorable for the transfer of cold air into the United States from the great continental cold region of western British America and the adjacent portions of Alaska. The direction of the winds, as in December, was again largely from northerly quadrants east of the Rocky Mountains, while over the Plateau and Pacific Coast States they maintained the same general tendency from the west and southwest as in December.

CHART XVIII. Departure of the mean temperature, January, 1918, from the normal, forcibly illustrates the influence of the pressure distribution, of the air movement and of snow cover on the temperature over the United States. The region with the greatest departure of temperature below the normal is practically coincident with that in which the snow cover was the most above normal. (See CHART XVII, Average depth of snow on the ground during January.) Considering CHARTS XII and XVII, showing departures of pressure from the normal for December and January, respectively, it is seen that while there was a great reduction in the average air pressure from the first month to the second over all northern districts, the gradient in each case is similar, high pressure toward the northwest and lower pressure toward the southeast, with a corresponding air drift from the cold Northwest into the central and eastern portions of the United States.

CONTRAST BETWEEN DECEMBER AND JANUARY.

Contrasting the pressure characteristics of the two months it will be observed that during December strong nticyclones were projected into the central portions of the United States from the high-pressure belt lying near the Arctic Circle. These in their passage southward were materially warmed by constant contact with a warmer atmosphere and, during a portion of the month, by a warmer earth's surface with unfrozen rivers and lakes still giving off their stored heat. Thus, although still cold, when they reached the interior of the United States, they were, nevertheless, many degrees warmer than when they started on their long journey.

During January, however, a wholly different type of distribution prevailed. There was, in the main, no great high-pressure area in the far north from which strong anticyclones could move southward, nor was the temperature steadily lower than usual over that region; but pressure was far below the normal over the southern and eastern districts of the United States. This condition set up a gradient that virtually drew from the northern districts air not abnormally cold for the season, which on passing over the nearly universal cover of snow and ice that had now accumulated over the greater part of the United States retained its original temperature to a much greater degree than during December.

DECEMBER AND JANUARY TEMPERATURES.

It is of interest to note that in December the average temperature at Dawson, in the British Yukon, was —51° F., and at Louisville, Ky., it was 26° F., a difference of 77 degrees. In January the average temperature at Dawson was —13° F., and at Louisville 20° F., a difference of only 33 degrees. Assuming that the temperatures in the United States east of the Rocky Mountains during the two months were to some extent influenced by those prevailing to the northward, as shown by the atmospheric drift, it is clear that local air and surface temperatures must have exerted a considerable influence in modifying the degree of cold experienced during the two months. In other words, had the conditions that apparently retarded the warming processes in January over the eastern United States prevailed to a like extent during December, we should expect that at Louisville the December average temperature, instead of being 26° F. above zero, would have been nearly as many degrees below that point. Or, had the cold over northern districts been as severe in January as in December and the rate of warming continued unchanged the mean temperature at Louisville for January should have been approximately —15° to —20° F.

We may, then, logically assume that the cause of the continued low temperatures over the eastern half of the United States during January, 1918, was in large measure the lingering after-effect of the unusual cold of the preceding month (1), augmented by the pressure gradient, moderate as compared with December, but which still encouraged the prevalence of northerly winds over the interior of the country.

IS COLDER WEATHER POSSIBLE?

Entering the field of speculation as to the opportunities for periods of more severe cold than have heretofore been officially recorded in the United States, the facts presented by the actual degree of cold that persisted in December, 1917, over the far northern districts of the western continent, and the opportunities for the penetration of such cold to lower latitudes without material warming up, as experienced in January, 1918, discloses the easy possibilities of unusual winter temperatures in the United States. It is quite within bounds to assume that cold weather similar to that of December, 1917,

might continue an additional month or more over the far northern districts, and with a similar pressure distribution to the southward; in which case, without any change in the orderly procession of the forces dominating our weather, there could easily exist in the United States temperatures continuously so far below previous records, as to substantiate fully as the truth the traditions of severe cold experienced in the past at similar latitudes in Europe.

RESULTS ATTENDING THE SEVERE COLD OF JANUARY, 1918, OVER THE EASTERN TWO-THIRDS OF THE UNITED STATES.

At the beginning of the month the ground was snow covered north of a line extending from South Carolina to the northern Rocky Mountain region. Frequent extensive storms sweeping well to the southward in their movements across the country added to the depth and surface extent of the snow, and by the middle of the month the greater part of the country was covered. The depths had reached unusual proportions in the Ohio and middle Mississippi Valleys and thence northward over the Lakes region and northeastward to New England. At points in these regions some of the heaviest snowfalls and severest drifting ever known occurred; and the great transportation lines were often badly crippled and at times completely paralyzed. Wagon roads were blocked for long periods, the distribution of food and fuel was greatly delayed and much actual suffering was experienced, particularly on account of the intense cold and the general scarcity of fuel.

Severe cold, deep snow, and the attendant disorganization of nearly all industrial activities persisted with only slight variations until the end of the month, except that during the last week some melting of the snow cover occurred over the southern drainage area of the Ohio and thence to northern Texas.

Much additional ice formed on the rivers and lakes during the month, and in some of the important producing sections the gathering of the crop was delayed because the thickness was too great to permit the use of the special implements employed in the work. On the Ohio and middle Mississippi Rivers the amount of ice at points was the greatest ever known. Gorges that formed in the Ohio early in December, 1917, held in some places throughout the month, and when they finally broke up late in January, or early in February, caused much damage to river interests (3). It is estimated that one-half the tonnage on the lower Ohio and portions of the middle Mississippi was destroyed by the heavy ice. At Cairo, Ill., it is reported that pedestrians crossed the Ohio River on the ice, an occurrence not previously related either in the known history or traditions of that place. At the mouth of the Chespeake Bay, where ordinarily no interruptions occur to traffic, there were 15 days during the month on which it was impracticable on account of the ice barriers to operate car floats between Cape Charles and Norfolk. Late reports from far northern regions indicate that the ice conditions were the worst in many years. In Hudson and Davis Straits, ice was observed in unprecedented quantity nearly all the past summer, and vessels that usually visit points in Hudson Bay during each summer, were unable to reach the more northern points on account of the heavy ice.

Farm work of all kinds remained practically at a standstill, much corn still remained in the fields ungathered, and wheat not protected by a snow cover was badly damaged by the cold. In the Southern States, winter oats were killed or their growth greatly retarded, and in the great winter trucking districts only the hardier vegetables made appreciable growth, and some that survived the cold of December were further damaged during January.

As in December, the weather conditions west of the Rocky Mountains were almost the reverse of those to the east. In these western regions warm westerly or southwesterly winds, induced by low areas entering the United States east of the Rocky Mountains and moving well southward along their eastern slopes, prevailed throughout the month. In the absence of important cyclonic activity in that region little snow occurred at the lower elevations, and most of what occurred in the high mountains soon disappeared under the influence of the warm winds. At the close of the month practically no snow had accumulated in the mountain regions of the West, particularly in the Sierra Nevada, where the deficiency in the snow cover was the greatest ever know at that period of the winter, and a serious shortage in the water supply for irrigation and power purposes during the summer months was indicated.

THE WEATHER DURING FEBRUARY, 1918.

At the beginning of the month severe cold still persisted over the districts east of the Rocky Mountains, particularly from central Texas northeastward to the Great Lakes. At the same time an offshoot from an extensive depression that had rapidly developed over Alaska and the North Pacific overspread the northwestern districts of the United States, and within the following few days moved rapidly across the country, bringing temporary relief.

Anticyclonic conditions were quickly reestablished, however, by the rapid southward movement of a high-pressure area that developed, apparently, in the region just west of Hudson Bay. By the morning of the 4th the whole interior of the country was under its influence, and throughout the Middle West some of the lowest temperatures of the winter were experienced.

SUDDEN APPEARANCE OF WARM WEATHER.

As this cold area moved to the Atlantic Coast, another offshoot from a great area of low pressure over the North Pacific, Alaska, and western Canada entered the northern districts of the United States, and by the morning of the 5th covered the entire region from the middle Mississippi Valley, Great Lakes, and Hudson Bay, westward. Warm, southerly winds had now set in over the Missouri Valley districts, the temperature had risen 20 to 40 degrees (F.) or more (cf. Fig. 4), and the first permanent break in the cold that had persisted so constantly since early in December, was at hand. The low pressure advanced rapidly eastward, and by the morning of the 7th temperatures were above normal in practically all portions of the country for the first time in about two months.

Following closely the low-pressure area noted above, another advanced into the Middle West, and temperatures remained above the seasonal average for several days. About the 8th, high pressure moved into the Pacific coast States and gradually overspread all central and southern districts of the United States. With low pressure over Canada, however, the winds over the northern districts continued from their southerly course and temperatures were maintained above the normal very generally until near the middle of the month.

CHART XX, February 10, 1918, illustrates the general type of pressure that favored warm weather over the interior and northern districts of the United States from about the 5th to 15th. The high pressure overlying the central and southern districts apparently entered the United States from the middle Pacific by way of California, and hence lacked the great mass of cold air attending highs that move from more northern latitudes.

CHART XXI, February 15, shows a return of pressure distribution favorable for the reestablishment of cold weather over the United States. On this date, high pressure dominated the entire region north of the United States, while in the South and East the pressure was low. This type persisted in modified forms till after the close of the second decade, during which time severe cold was experienced more or less constantly in all northern districts east of the Rocky Mountains. The extreme cold of the earlier months of the winter was not reached, due probably to the absence of an extensive snow cover and the lessened opportunities for the cold winds from the north to maintain their initial temperatures.

CHART XXII, February 23, typifies the pressure conditions existing during the last week of the month. The atmospheric circulation had now returned to the type existing earlier in the month; low pressure over the whole of British America with the center west of Hudson Bay, and moderately high pressure in the Gulf region and west to the Pacific. Air movement over the greater part of the United States was again from the south and unusually warm weather prevailed over the greater part of the country till the close of the month.

FEBRUARY MEAN PRESSURES AND TEMPERATURES.

CHART XXIII shows the average pressure distribution during February, 1918, and the general course of the prevailing winds, while CHART XXIV indicates the departure of the temperature from the normal. The almost uniform prevalence of southerly winds east of the 100th meridian clearly illustrates the effect of the pressure distribution and explains at once the unusual warmth that persisted during so much of the month as compared with the cold of the two months preceding. For the month as a whole the temperature averaged well above the normal over the greater part of the country, particularly in the central valleys, where it was in marked contrast with that of the preceding two months. The heavy body of snow on the ground at the beginning of the month disappeared rapidly, and at the close only the northern districts were snowbound. The breaking up of the heavy ice in the rivers and the discharge of the excess of water resulting from the large accumulation of snow was accomplished with much less damage and loss by overflow than had been feared, although in the Ohio and some of its tributaries the formation of several extensive gorges caused considerable damage.

The milder weather of February brought much relief to the mining and transportation interests and greatly relieved the suffering from cold due to a general scarcity of coal and other fuels. Much progress was made in farming operations usual to the winter season, which had been practically at a standstill since early in December.

Winter grains, which had entered the season in poor condition generally, and in portions of the important producing sections had been subjected to severe cold from lack of snow cover, responded to the favorable weather of the month in general and at the close gave promise of a much greater yield than was considered possible at the beginning.

COMPARISONS WITH PREVIOUS RECORDS.

Meteorological records made upon a basis sufficiently uniform for comparison as to the larger fluctuations of the weather have been maintained at a few points in the United States for more than a century, the longest records naturally being found in the earlier settled districts near the Atlantic seaboard. With the advance of civilization westward, interest in weather conditions was still maintained by individuals, who started new records at widely scattered points, despite the stress of existence; so we find as far west as the Mississippi River records extending back into the early part of the last century. At St. Paul, there is an authentic record of the daily and monthly temperatures running back to 1820, and at St. Louis, Mo., the record began in 1833, while at several points farther east, notably in Ohio, observations of weather conditions were begun nearly 100 years ago.

Examination of the records for all these years fails, in many cases, to disclose a winter with two consecutive months having as long continuous cold and as low average temperature as was experienced during the past winter. Along the northern border of the United States, as at St. Paul, Minn., the period in some cases was not the coldest of record in nearly 100 years; the mean temperature for December and January of the past winter was slightly higher than the same months of some other years, notably for December, 1857, and January, 1858. But at St. Louis, Mo., the mean temperature for the two months in question is the lowest in more than 80 years, and this is true to a very general degree over all interior and southeastern districts of the United States east of the Plains region.

At Portsmouth, Ohio, with a record of nearly 95 years, we find December and January of the past winter the coldest of record for the entire period. At Baltimore, Md., the record extends back more than 100 years, 1817 to 1918, during which time no two months combined had as low mean temperature as was recorded during December and January of last winter; although individual months had mean temperatures as low as, or lower than, either December or January, notably December, 1831, 1.4 degrees (F.) lower, and 1870, the same as December, 1917; while January, 1857, and 1893, were only slightly warmer than January, 1918. In more than a hundred years record at Philadelphia no combination of December and January temperatures gives a mean so low as that of December and January of the past winter, but the mean for January, 1857, 22.4° (F.), was 1.8 degrees (F.) lower than the past January, and that of January, 1856, 24.1° (F.), was 0.1 degree (F.) lower. The winter approaching nearest that just past in degree of cold on the average, particularly over the eastern districts, was that of 1856–57, December, 1856, being, as a rule, warmer than the same month in 1917, with January, 1857, somewhat colder than the same month of 1918. In portions of Northwestern Canada and over interior Alaska, December, 1917, was by far the coldest month of which there is official or other record.

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EFFECTS OF COLD WEATHER, WINTER OF 1917-18, ON VEGETATION.

By J. WARREN SMITH, Meteorologist.

The unusually persistent cold weather during the months of December, 1917, and January, 1918, did not result in serious damage to the winter grains, fruit, and truck crops. In much of the Great Plains, the upper Mississippi Valley and the Lake region, there was some deterioration in the condition of winter wheat at the beginning of April, 1918, as compared with its condition on entering the winter, but in the first-named district much of the harm resulted, indirectly at least, from the poor condition of the plants due to the dry fall. In the middle Mississippi and Ohio Valleys and in most central and northern districts farther east, wheat was unusually well protected by a heavy snow cover during the prevalence of the cold weather, and by the first of April substantial improvement was reported in the condition of the crop over that at the beginning of the winter. On the whole, the unusually favorable spring in the principal wheat belt more than offset any damage that wheat may have sustained from winter killing.

Winter oats and truck crops in the southern States were much damaged, however, by the unusually severe winter weather, and considerable loss in stored vegetables was sustained where proper precautions had not been taken. There was also quite serious loss of unprotected cattle in some sections, particularly in Texas, where stock was in a weakened condition from lack of sufficient feed due to the protracted drought.

Except for winter killing of peach buds and some young peach trees from Arkansas and Missouri northeastward to New England and considerable damage to other fruit about the Lakes, fruit suffered little damage from the cold. Apples, citrus fruit, and cranberries were not unfavorably affected generally, except for some winter killing of cranberries in dry bogs of the Cape Cod district.

SECTION III.—FORECASTS AND WARNINGS.

FORECASTS AND WARNINGS, DECEMBER, 1918.

By H. C. FRANKENFIELD, Supervising Forecaster.

[Dated: Washington, Jan. 9, 1919.]

GENERAL PRESSURE DISTRIBUTION OVER THE NORTHERN HEMISPHERE, EXCEPT EUROPE AND ASIA.

Over the Pacific Ocean pressure was above normal during the month, especially from the 2d to the 7th, inclusive, over that section in which Midway Island is located. Over the Aleutian Islands and Alaska the mean pressure was somewhat below normal, although quite high over extreme southern Alaska during the third decade of the month, the rise extending over interior Alaska during the last three days.

Over the United States proper there were no marked extremes of pressure, except from Ontario eastward where there was about a week of rather high pressure after the middle of the month. As a whole the pressure was somewhat below normal, except over the Canadian Northeast. Over the southwestern Atlantic Ocean, as indicated by the reports from Turks Island, West Indies, pressure was normal throughout the month, increasing to the northward after the first five days. On the 28th a disturbance passed the Island of Bermuda, moving northward, and on the 29th it was over Cabot Strait, with a barometer reading of 28.98 inches at Port Aux Basque, Newfoundland.

Reports from Horta in the eastern Atlantic were generally missing until the 20th, from which time until the end of the month moderately high pressure prevailed.

STORM WARNINGS.

A disturbance that was over western Minnesota on the 1st did not develop as strongly as had been anticipated, and storm warnings ordered at 4 p. m. for the Upper Lakes were not generally justified, although some moderately strong winds occurred on Lakes Michigan and Huron. There was a similar failure in development of a disturbance that was over northeastern Florida on the evening of the 1st, and a consequent absence of strong winds on the South and Middle Atlantic coasts, in anticipation of which northeast storm warnings were ordered at 10 p. m.

On the morning of the 2d, with the lake disturbance over Upper Michigan, small craft warnings were ordered from Port Huron, Mich., to Cleveland, Ohio, and southwest storm warnings from Erie, Pa., to Oswego, N. Y. These warnings were well verified, except on Lake Ontario. This disturbance continued eastward, and on the morning of the 4th, when it was central over eastern New York, northwest warnings were ordered along the Atlantic Coast from Sandy Hook, N. J., to Nantucket, Mass. Fresh gales followed.

On the 5th another northwest disturbance was central over Minnesota with an increasing tendency, and at 3 p. m. northwest and northeast warnings were ordered displayed on the Upper Lakes, except southern Huron. These warnings were also justified by the succeeding occurrences, except on western Michigan and eastern Superior. The evening observation of the 5th indicated a still further increase in intensity of this storm, coupled with a more rapid easterly movement, and at 10:30 p. m. southwest warnings were ordered on the Atlantic Coast from Norfolk to Boston, and northwest and southwest warnings on the Great Lakes from Detroit to Oswego. These warnings were followed by strong winds as had been indicated, New York City and Block Island, R. I., reporting maximum velocities of 72 and 56 miles an hour, respectively, from the Northwest during the 6th. The warnings on the Atlantic coast had previously been changed from southwest to northwest.

On the morning of the 9th a Middle Plateau disturbance was central over northeast Nebraska in marked form, and at 10 a. m. northeast and southeast warnings were ordered on the upper Lakes for strong winds during the following afternoon and night. The disturbance did not develop materially, but a considerable increase in pressure to the northeastward created a strong gradient to the southwestward, and strong winds occurred during the ensuing 24 to 36 hours, the warnings having been continued on the morning of the 10th over the northern half of the region, with small-craft warnings over the southern half. Small-craft warnings were also ordered on the Atlantic coast from Norfolk to Boston for fresh to strong northeast winds.

By the evening of the 10th there was a more definite movement of the western disturbance, with its center over Indiana, and with strong high pressure to the northeastward, and at 10:30 p. m. southeast warnings were ordered on Lake Erie from Cleveland to Buffalo and on Lake Ontario. No strong winds followed, however, except in the vicinity of Erie, Pa. On the morning of the 11th on eastern Lake Superior and extreme northern Lake Huron the warnings were changed to southeast, another northwestern disturbance having moved to western Lake Superior. This disturbance moved northeastward, and no strong winds occurred.

The display of storm warnings on the Great Lakes was discontinued for the season at the termination of December 15.

On the morning of the 15th there was a very moderate depression off the North Carolina coast after a very slow four-day movement across the country from extreme southern California, while very high pressure prevailed to the northward. This distribution resulted in moderate gales along the Atlantic coast from Cape Henry to Nantucket during the 16th and 17th for which no warnings had been ordered.

On the evening of the 19th there was a moderate depression over the lower Rio Grande Valley, with widespread and marked high pressure throughout the eastern half of the country. Accordingly, northeast storm warnings were ordered on the Gulf coast from Bay St. Louis, Miss., to Cedar Keys, Fla., and on the Atlantic coast from Jacksonville, Fla., to Georgetown, S. C. On the following day fresh southeast gales occurred on the middle Gulf coast, but only fresh winds at other places where the warnings had been displayed. An offshoot from a plateau disturbance was over eastern Texas on the morning of the 23d, with much higher pressure to the northward, and at 11 a. m. southeast storm warnings were ordered on the Gulf coast from Bay St. Louis to Carrabelle, winds to become strong from east and south east, and to shift to colder west and northwest on the following day. During the night the wind at Pensacola, Fla., reached a velocity of 64 miles an hour from the southwest. At 9:45 p. m., with the disturbance over the lower Mississippi Valley, advisory warnings of strong northeast winds with snow were sent to open ports on Lake Michigan.

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The disturbance moved northeastward with perhaps the best storm development of the month, and snows and strong winds occurred as forecast. At 8 p. m., December 24, the disturbance was over western Lake Erie, with a secondary center over New Jersey, and at 10:30 p. m. southeast warnings were ordered displayed on the New England coast.

However, although the pressure decreased during the night, there were no strong winds of consequence, and the warnings were lowered at 10:30 a. m. of the 25th, and small-craft warnings ordered displayed at New York City and Sandy Hook, N. J., for the strong northwest winds that followed during the day.

The last warning of the month and year was an advisory one for open ports on Lake Michigan. It was issued at 9:30 p. m. of the 30th, at which time a southwestern disturbance was central over eastern Iowa with a northeastward movement. Strong winds becoming north and northwest with snow and rapidly falling temperature were forecast. Snow followed, but the winds were not more than fresh, and the temperature fall was delayed by the rapid development and northeastward movement of another southwestern disturbance.

COLD WAVE AND FROST WARNINGS.

Following the moderate disturbance that was off the North Carolina Coast on the morning of the 2d, warnings of heavy frost on the following morning were issued fo the East Gulf and South Atlantic States (light frost for central Florida). Frosts occurred generally, but they were mainly light. From this time until the 22d there was no occasion for the issue of frost warnings. On the morning of the 22d, with high pressure and low temperatures to the northwestward, and a well-defined disturbance over eastern Texas, cold wave warnings were issued for southern Kentucky, Tennessee, northern Mississippi, and northern Alabama, and for freezing temperatures, or lower, for southern Mississippi and southern Alabama by the morning of the 24th. On the evening of the 23d freezing temperatures were forecast for the morning of the 25th over northwestern Florida. The very slow northeastward movement of the Texas disturbance delayed the approach of the cold weather, and it did not arrive until the morning of the 26th, when freezing temperatures occurred into northwest Florida, with a moderate cold wave to the northward. The warnings for the Southern States were repeated on the morning of the 26th, and they were generally verified over the northern districts, cloudy weather prevailing to the southward. The frosts and freezing temperatures that occurred over northern and central Florida on the morning of the 30th were not forecast, the assumption being that the weather would remain more or less cloudy. However, the clouds soon reappeared and there were no frosts on the following morning.

On the evening of the 30th and the morning of the 31st there was a strong and decidedly cold high-pressure area over the North and Northwest, with a trough of moderately low pressure extending from Texas to the Upper Mississippi Valley, and warnings for a moderate cold wave were ordered for northern Mississippi, western Tennessee, the Ohio Valley, Indiana, Lower Michigan, and extreme northwestern Upper Michigan. These cold-wave warnings were generally verified, although the low temperatures were somewhat delayed in some localities by the slow movement of the depression to the eastward.

A single warning of substantial snowfall was issued in the late afternoon of the 23d for southern Lower Michigan, northern and central Indiana and northwestern Ohio, and the warning was well verified, except in central Indiana and northwestern Ohio.

WARNINGS FROM OTHER DISTRICTS.

Chicago, Ill., forecast district.—The month throughout the entire district was uneventful during the first two decades, mild temperature being the rule. During the last decade the weather conditions were quite active; first, because of the development and movement on the 23d and 24th of a severe storm from the southwest over the middle States; and second, because of another development a few days later of a storm and cold wave in the west.

The first storm brought general and heavy precipitation, mostly in the form of snow, with strong shifting winds. The conditions attending this storm were correctly forecast, and the area of precipitation closely defined, with the exception of the State of Wisconsin. It was not anticipated that the track of the storm would be far enough to the north to bring snow to that State. No marked cold followed this storm movement, except in the middle Plains States, where there was a gradual fall in temperature, and on this account cold-wave warnings were not issued nor justified.

During the closing days of the month the second storm which moved across the district was followed by a well-marked cold wave, with considerable falls in temperature. This storm developed on the eastern slope of the Rockies on December 29, moving southeastward to Texas, and thence northeastward over the Middle States, reaching the Great Lakes region by the 30th and 31st. The storm was accompanied by precipitation over a wide area, and the ensuing temperatures were by far the lowest experienced during the month. Warnings were issued for all sections affected. On the morning of December 29 warnings for snow, colder, and strong shifting winds were sent to stock and transportation interests in Montana, Dakotas, Minnesota, east and central Wyoming, and western Nebraska. On the evening of that day cold wave warnings were issued to the Dakotas, east and south Montana, Wyoming, western Minnesota, Nebraska, Kansas, and northwest Iowa. On the morning of the 30th cold wave warnings were repeated to western Minnesota, South Dakota, Nebraska, Kansas, and northwest Iowa. In the afternoon and night they were extended to eastern Minnesota and western Missouri, western Wisconsin and western and northern Iowa, and on the morning and afternoon of the 31st, over the balance of Iowa and Missouri, and in the evening to Illinois.

The cold wave did not move directly southeastward from the northwest, but rather in a roundabout way, first directly southward over the Plains States, and then finally eastward, not reaching Illinois until January 1, and eastern Wisconsin until January 2.

Doubtless the warnings issued were of great value, especially because of the moderate weather conditions preceding, although much information is not available at the time of writing. Under date of December 30, the section director in Cheyenne, in his weather and range report for Wyoming, reports, as follows:

> Sunday morning warnings were sent out advising stockmen and shippers of approaching stormy weather with snow and colder. By Tuesday morning temperatures of 18 below zero were common over the central and north parts of the State, while snow had occurred over much of the State, being heavy in the Lander district.

Under date of December 23, Mr. P. H. McCauley, superintendent of transportation of the Northern Pacific Railway Co., St. Paul, writes, as follows:

> Your wire yesterday giving prospective weather conditions received. This is first of the season and reminds us of the many similar advices

received last winter, which we were very glad to get, as they were always reliable and immediately telegraphed to our superintendents in the territory where weather changes are effective, the necessary action being taken for as much protection as possible. Hope that you will continue long in this service, as it has proven very reliable in the past.—*H. J. Cox.*

New Orleans, La., forecast district.—Frost or freezing warnings were issued on the 2d, 3d, 4th, 10th, 13th, 14th, 25th, 26th, and 28th, and were generally justified.

On December 23 an area of low pressure was centered over Texas and an area of high pressure to the northward with its crest over the Dakotas, where the temperature was zero to 10° below, indicating that a cold wave would extend to the Gulf coast. Cold-wave warnings were ordered on the a. m. map for Arkansas, Oklahoma, eastern Texas except Abilene, and for northwest Louisiana, and extended at night over Louisiana. The cold wave occurred as forecast at nearly all stations.

On December 30 the a. m. map showed an area of low barometer over the southern Rocky Mountain region and the Plains and West Gulf States, and an intense high pressure area to the northward. The conditions indicated that the low pressure from the southern Rocky Mountain region would develop southward into Texas and give a general and severe cold wave over this district. Cold-wave warnings were issued on the morning of the 30th for Oklahoma and the northern portion of west Texas, were extended at 3 p. m. to El Paso, Abilene, and Del Rio, and at 9:30 p. m. to all stations except the Gulf coast and eastern Arkansas. On the morning of the 31st warnings were issued for Arkansas, Oklahoma, the northeast and southwest portions of east Texas, and were extended to the Texas and Louisiana coasts at 3 3 p. m. Warnings were repeated at night to Louisiana, Arkansas, and eastern Texas except the northwest portion. A severe cold wave overspread the district, giving the minimum temperatures forecast in nearly all localites.

Live-stock warnings were issued on the 23d, 30th, and 31st.

Storm warnings were ordered for the Louisiana and Texas coasts on the 19th and 23d, and for the Texas coast on the 31st.—*I. M. Cline.*

Denver, Colo., forecast district.—No severe weather conditions requiring warnings occurred during the first and second decades. On the 21st a Pacific storm was central in Arizona, while an anticyclone was spreading southward over the northern Rocky Mountain region and the north Pacific States. Live-stock warnings were issued at 9:10 a. m. for the greater portion of eastern Colorado. Moderate to heavy snow fell and temperatures ranging from zero to 10° occurred in northeast Colorado. A portion of the storm moved southeastward into Mexico and reappeared on the Texas coast on the 23d, while the part remaining in Arizona dissipated. On the 29th an area of low pressure developed in the southern Plateau region, and at 8 p. m. warnings of a moderate cold wave were issued for northeast Colorado, as the pressure was increasing rapidly in the Canadian Northwest, while the southwestern depression increased in intensity. The following morning cold wave warnings were repeated for eastern Colorado, with a prediction of zero temperatures, and live-stock warnings were distributed. A moderate cold wave warning was also issued for districts in New Mexico east of the mountains. The warnings were fully verified. At 8 a. m. on the 31st the storm had moved slowly eastward to western New Mexico. Cold-wave warnings were ordered for northwest New Mexico and extreme southwest Colorado and a warning of freezing temperature, with probably frost in localities, was issued for southwest Arizona. A sharp fall in temperature occurred on the morning of January 1st in the southern and central portions of the district, with temperatures considerably below zero in southern Utah, northern Arizona, northwest New Mexico, and Colorado. At Phœnix the lowest temperature was 26° and at Yuma, 28°.—*Frederick W. Brist.*

San Francisco, Cal., forecast district.—December weather in this district was largely controlled by high-pressure areas and, consequently, there was a predominence of fair weather with temperature below normal, especially at night. In the Sacramento Valley there were 18, and in the San Joaquin Valley 17 mornings with frost. Near the end of the month citrus fruit was badly damaged in a number of localities south of the Tehachapi. Warnings for frost in some one or more localities in California were issued on 26 days, and in nearly every instance they were verified. Forecasts of the minimum temperature expected at Pomona, in the heart of the orange district, were made every day, based upon information contained in the p. m. weather chart. These forecasts reached Pomona before 7 p. m., at which time our representative there amplified them to meet local conditions in the neighborhood. These forecasts, except on two or three occasions, were within two or three degrees of the exact temperatures registered by the minimum thermometer in the instrument shelter placed on the ground at Pomona. The greatest departure occurred on the morning of the 30th. It was raining at Pomona at observation time of the previous evening, and the conditions seemed to indicate that the rain might continue and be accompanied by winds sufficiently strong to prevent any great drop in temperature. A minimum temperature of 32° was predicted, but shortly before daylight the weather became still and clear, and the temperature quickly dropped to a minimum of 22°. Not much orchard heating was done on this night, but it is believed the damage was not great on account of the short time the minimum temperature below the freezing point.

Storm warnings were issued on 13 days, and small craft warning on eight days for one or more places in this district. Most of the warnings were placed at the entrances to the Strait of Juan de Fuca and the Gulf of Georgia, and at the mouth of the Columbia River, for storms central over southeastern Alaska, the outer edge of which barely reached to the northwest corner of the United States, but they caused a strong draft of air through the relatively narrow courses where the displays were placed, and much stronger winds were experienced after leaving the confines of the United States by vessels bound northward. The worst storms of the month occurred during the morning of the 28th, when a maximum wind velocity of 78 miles an hour from the southeast was reported from North Head, Wash., and during the 12 hours between 5 p. m., December 19, and 5 a. m., December 20, when a maximum velocity of 85 miles an hour from the northwest occurred at Point Reyes, Cal. Warnings for the North Head storm were ordered the evening before it occurred, and for the Point Reyes storm the morning before the high winds began. It is probable the oil-tank steamer *George Loomis*, 401 tons net, with a crew of 17 men, was so damaged by the storm of the 20th that she afterwards foundered with the loss of all hands. This vessel left San Francisco on the 19th, bound for Coos Bay, with a cargo of oil. She was seen by passing vessels on the 21st and 22d but since then no trace of her has been found.—*E. A. Beals.*

SECTION IV.—RIVERS AND FLOODS.

RIVERS AND FLOODS, DECEMBER, 1918.

By ALFRED J. HENRY, Meteorologist in Charge.

[Dated: Weather Bureau, Washington, Jan. 30, 1919.]

The conditions of the streams on December 31, 1918, as regards thickness of ice, was in strong contrast with that of a year ago.

At this writing, January 30, 1919, it seems reasonably certain that the probability of destructive floods in the rivers, due to the breaking up of ice, is remote. The probability of a rain flood is always present.

General moderate to heavy rains caused most of the streams in the South Atlantic drainage to slightly exceed flood stages about the 15th to 18th and again about the 22d to 27th. Comparatively little damage was done by high water. Timely warnings resulted in saving a good deal of live stock that was pastured along the rivers.

Heavy rains in the East Gulf States from the 19th to 21st, caused moderate floods in most of the rivers during the last decade. The West Pearl River was also slightly above flood stage from the 3d to the 5th.

Slight floods occurred in the Maumee and St. Joseph Rivers, in Indiana and Ohio on the 15th and 22d.

Heavy rains were general over the Wabash River Valley on the 14th, causing a rapid rise at all points. The crest stages were not unusually high, but a great deal of damage was done to corn that had not been shucked.

Heavy rains in the French Broad River Valley caused the river to overflow on the 15th and again on the 22d. But little damage resulted, except to bridges and roads. The high water of the 22d caused the Tennessee River to exceed the flood stage to below Knoxville, Tenn.

The Illinois River was slightly above flood stage at Peru, Henry, and Beardstown, Ill., during the latter part of the month.

Slight floods occurred in most of the rivers of Arkansas and in the Sulphur River in Texas from the 14th to the 18th and in the Cache River in Arkansas from the 29th to the end of the month. No damage was reported in Arkansas. Considerable damage was caused to crops and live stock near Ringo Crossing, Tex. The high water near Findley, Tex., prevented prompt repairs to a gas pipe line, causing about $150,000 damage.

Flood stages were exceeded on the Upper Trinity River as far down as Liberty, Tex. The first rise began on the 15th and the second on the 21st. The river was still in flood at Trinidad and Liberty, Tex., at the end of the month. No damage resulted from these rises.

The usual tables follow:

Losses in December, 1918, due to floods.

District.	Bridges, highways, etc.	Crops.		Farm property, live stock, etc.	Suspension of business.	Value of warnings.
		Gathered.	Prospective.			
Columbia, S. C.	*$6,250					$73,250
Charleston, S. C.	1,100	$500		$400	$8,000	20,000
Montgomery, Ala.		200				1,000
Terre Haute, Ind.		200,000	$50,000			50,000
Indianapolis, Ind.	*15,000					
Asheville, N. C.	8,000			40		1,000
Shreveport, La.	500	2,500		2,000	150,000	2,000
Total	30,850	203,850	50,000	2,440	158,000	147,250

*Includes farm property, etc.

TABLE I.—*Flood stages in the Atlantic drainage during December, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
James:	*Feet.*			*Feet.*	
Buchanan, Va.	15			14.7	23
Columbia, Va.	18	24	24	19.6	24
Roanoke:					
Weldon, N. C.	30	25	25	32.8	25
Tar:					
Rocky Mount, N. C.	9			8.4	19
Greenville, N. C.	13			12.3	23
Fishing Creek:					
Enfield, N. C.	14	18	18	14.6	18
Neuse:					
Neuse, N. C.	14	18	20	15.4	19
Smithfield, N. C.	14	18	21	15.3	18
Cape Fear:					
Elizabethtown, N. C.	22	19	19	22.5	19
Peedee:					
Cheraw, S. C.	27	19	19	28.6	19
Do		25	26	30.3	25
Santee:					
Rimini, S. C.	12	(*)	6	14.2	4
Do		17	(**)	18.6	29
Ferguson, S. C.	12	2	9	13.4	5–6
Do		19	(**)	14.5	30
Catawba:					
Catawba, S. C.	11	17	17	11.0	17
Do		23	25	14.1	23
Wateree:					
Camden, S. C.	24	17	18	26.7	18
Do		24	26	29.6	24
Congaree:					
Columbia, S. C.	15	24	24	15.7	24
Broad:					
Blairs, S. C.	15	23	24	17.0	23–24
Carlton, Ga.	4	22	26	20.0	22
Saluda:					
Pelzer, S. C.	7	16	17	8.6	16
Do		22	25	13.0	23
Chappells, S. C.	14	16	19	19.4	18
Do		22	27	20.0	25
Savannah:					
Calhoun Falls, S. C.	15	23	23	15.9	23
Augusta, Ga.	32	24	24	35.0	24
Ocmulgee:					
Dublin, Ga.	22			18.9	29
Milledgeville, Ga.	22			21.3	23
Ocmulgee:					
Macon, Ga.	18	23	24	19.4	23
Abbeville, Ga.	11	27	(**)	14.8	29

* Continued from November. ** Continued into January.

TABLE II.—*Flood stages in East Gulf drainage during December, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Flint:	*Feet.*			*Feet.*	
Woodbury, Ga.	10	23	24	10.5	24
Montezuma, Ga.	20			18.8	25
Albany, Ga.	20	28	(**)	23.3	30
Bainbridge, Ga.	25			23.5	31
Chattahoochee:					
Norcross, Ga.	16	23	24	21.3	23
West Point, Ga.	20	22	23	22.1	23
Columbus, Ga.	20	21	*	41.5	23
Eufaula, Ala.	40	22	27	53.0	23
Alaga, Ala.	30	22	29	40.8	25
Alabama:					
Montgomery, Ala.	35	23	28	45.0	25
Selma, Ala.	35	23	30	46.4	26–27
Tallapoosa:					
Milstead, Ala.	40	22	23	46.4	22
Coosa:					
Rome, Ga.	30			27.9	24
Gadsden, Ala.	22	26	26	22.0	26
Lock, No. 4, Lincoln, Ala.	17	24	29	18.0	25–26
Wetumpka, Ala.	45			44.3	24
Etowah:					
Canton, Ga.	11	22	23	23.0	22
Tombigbee:					
Demopolis, Ala.	39			38.5	26
Pascagoula:					
Merril, Miss.	20			18.2	26–27
West Pearl:					
Pearl River, La.	13	3	5	13.8	4
Do		25	(**)	14.0	29

** Continued into January.

TABLE III.—*Flood stages in the Great Lakes drainage during December, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Maumee:	*Feet.*			*Feet.*	
Fort Wayne, Ind.	15	15	16	16.1	15
Do.		22	26	17.6	23
St. Joseph:					
Montpelier, Ohio.	10	15	15	10.6	15
Do.		22	25	11.8	23

TABLE IV.—*Flood stages in the Mississippi River drainage during December, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Scioto:	*Feet.*			*Feet.*	
Circleville.	7			6.4	16
Wabash:					
Lafayette, Ind.	11	15	18	17.6	16
Do.		22	28	19.7	24–25
Terre Haute, Ind.	16	21	(**)	19.0	27
Vincennes, Ind.	14	21	(**)	17.4	30
Mount Carmel, Ill.	15	15	(**)	21.5	30
White:					
Decker, Ind.	18	18	(**)	19.9	22
White, West Fork:					
Noblesville, Ind.	14			12.1	15
Elliston, Ind.	19	14	19	23.0	17
Do.		22	28	25.2	26
French Broad:					
Penrose, N. C.	13	22	25	20.2	22
Asheville, N. C.	4	15	15	4.0	15
Do.		17	17	4.5	17
Do.		22	26	9.0	23
Marshall, N. C.	10			9.5	23
Danbridge, Tenn.	12			11.6	23
Big Pigeon:					
Newport, Tenn.	6	22	22	10.0	22
Tennessee:					
Knoxville, Tenn.	12	23	25	13.0	24
Riverton, Ala.	32			29.5	28
Little Tennessee:					
McGhee, Tenn.	20			18.8	23
Hiwassee:					
Charleston, Tenn.	22	23	23	22.5	23
Illinois:					
Morris, Ill.	13			11.9	24
Peru, Ill.	14	22	(**)	15.1	25, 27–28
Henry, Ill.	7	20	(**)	9.0	29–30
Peoria, Ill.	16			15.9	31
Havana, Ill.	14			12.9	31
Beardstown, Ill.	12	30	(**)	12.3	31
Meramec:					
Pacific, Mo.	11			10.3	16
Ouachita:					
Arkadelphia, Ark.	18	14	15	18.6	14
Camden, Ark.	30	19	19	30.2	19
Petit Jean:					
Danville, Ark.	20	14	18	24.3	15–16
White:					
Batesville, Ark.	23			21.5	15
Georgetown, Ark.	22			21.4	24–25
Black:					
Black Rock, Ark.	14	14	(**)	19.4	14
Cache:					
Jelks, Ark.	9	29	(**)	9.6	31
Little:					
White Cliffs, Ark.	28	16	17	28.7	16
Sulphur:					
Finley, Tex.	24	17	20	27.8	18
Ringo Crossing, Tex.	20	14	15	25.0	14

* Continued from November. **Continued into January.

TABLE V.—*Flood stages in the West Gulf drainage during December, 1918.*

River and station.	Flood stage.	Above flood stages—dates.		Crest.	
		From—	To—	Stage.	Date.
Trinity:	*Feet.*			*Feet.*	
Dallas, Tex.	25	21	28	32.2	25
Trinidad, Tex.	28	15	20	32.9	17
Do.		26	(**)	33.6	31
Long Lake, Tex.	40	21	21	40.6	21
Liberty, Tex.	25	(*)	8	25.7	4–6
Do.		31	(**)	25.0	31
Bridgeport.	25			20.0	23
Colorado:					
Columbus, Tex.	28			26.4	26

*Continued from November. **Continued into January.

SNOWFALL IN THE HIGH MOUNTAINS, DECEMBER, 1918.

The meteorological conditions during the month were not conducive to heavy snowfall in the mountains. The snowstorms were more or less local in that thay prevailed over different parts of the mountain region on different dates; there was no single period of snowfall that affected all parts of the region alike. High pressure prevailed almost continuously throughout the month.

In the southern part of the Rocky Mountain and Plateau region there was considerable snow on the high altitudes at the close of November and this snow seems to have been fairly well conserved during December. Temperature was quite uniformly below the normal in this region, possibly as a result of the snow cover on the higher altitudes.

MEAN LAKE LEVELS DURING DECEMBER, 1918.

By UNITED STATES LAKE SURVEY.

[Dated: Detroit, Mich., Jan. 6, 1919.]

The following data are reported in the "Notice to Mariners" of the above date:

Data.	Lakes.*			
	Superior.	Michigan and Huron.	Erie.	Ontario.
Mean level during December, 1918:	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Above mean sea level at New York.	602.42	581.05	572.21	245.39
Above or below—				
Mean stage of November, 1918.	−0.12	−0.07	−0.03	−0.11
Mean stage of December, 1917.	+0.28	+0.25	−0.35	−0.56
Average stage for December, last 10 years.	+0.17	+0.03	+0.60	+0.52
Highest recorded December stage.	−0.71	−1.53	−1.32	−1.72
Lowest recorded December stage.	+1.22	+2.05	+1.35	+2.46
Average relation of the December level to—				
November level.		−0.2	−0.2	−0.2
January level.		+0.2	+0.1	+0.1

* Lake St. Clair's level: In December, 575.42 feet.

SECTION V.—SEISMOLOGY.

SEISMOLOGICAL REPORTS FOR DECEMBER, 1918.

W. J. HUMPHREYS, Professor in Charge.

[Dated: Seismological Investigations, Weather Bureau, Feb. 3, 1919.]

TABLE 1.—*Noninstrumental earthquake reports, December, 1918.*

Day.	Approximate time, Greenwich Civil.	Station.	Approximate latitude.	Approximate longitude.	Intensity Rossi-Forel.	Number of shocks.	Duration.	Sounds.	Remarks.	Observer.
		CALIFORNIA.								
1918.	*H. m.*		° ′	° ′			*M. s.*			
Dec. 5	2 38	Paso Robles	35 37	120 42	4	1	5	Rumbling	Abrupt rocking	E. J. Nye.
		San Luis Obispo	35 18	120 39	2	1	Few.	None	Trembling	J. E. Hissong.
14	10 00	San Miguel Island	34 02	120 20	4	1		None		James R. Moore.
29	6 50	Calexico	32 41	115 30	2	1		Rumbling	Bumping	H. M. Rouse.
	7 00	.....do	32 41	115 30	1	1	1	None	.....do	Do.
		OREGON.								
6	8 45	Portland	45 32	122 41	1	6	12	Faint	Gradual rocking	Helen J. Olson.
		WASHINGTON.								
6	8 45	Seattle	47 38	122 20		1				Associated Press.

TABLE 2.—*Instrumental reports, October, 1918.*

(Time used: Mean Greenwich, midnight to midnight. Nomenclature: International.)

[For significance of symbols see REVIEW for January, 1918, p. 34.]

Alabama. *Mobile. Spring Hill College.* Cyril Ruhlmann, S. J.

Lat., 30° 41′ 44″ N.; long., 88° 08′ 46″ W. Elevation, 60 meters.
Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. $V = —$, $T_0 = —$, $\epsilon = —$

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	e	10 03 00	.....	.....	.....	6,350	N undamped.
4	.....	eP	11 57 50	.....	.....	.....	.....	
		P_{repl}	12 00 20	.....	.....	.....	.....	
		S_N	12 05 45	.....	.....	.....	.....	
		F	13 19 00	.....	.....	.....	.....	
6	.....	eP	8 47 50	.....	.....	.....	.....	
		iS	8 53 28	.....	.....	.....	.....	
		S_{repl}	8 59 20	8	*1,000	*3,500	.....	
		L_N	9 00 50	6	.....	*29,000	.....	
		L_E	9 01 02	6	*5,000	.....	.....	
		M_N	9 01 22	6	.....	*31,000	.....	
		M_E	9 02 20	6	*5,500	.....	.....	
		M_N	9 03 50	5	.....	*15,000	.....	
		F	9 36 00	.....	.....	.....	.....	
6	.....	e	12 21 20	.....	.....	.....	.....	
		F	12 36 00	.....	.....	.....	.....	

* Trace amplitude.

Alaska. *Sitka. Magnetic Observatory.* U. S. Coast and Geodetic Survey. F. P. Ulrich.

Lat., 57° 03′ 00″ N.; long., 135° 30′ 06″ W. Elevation, 15.2 meters.
Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. E: $V = 10$, $T_0 = 18$; N: $V = 10$, $T_0 = 17$

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 4	.....	eL_E	12 56 ..	.....	.....	.....	.....	Only a few long waves.
		M_E	13 01 ..	18	10	.....	.....	
		C_E	13 05 ..	.....	.....	.....	.....	
6	.....	P_E	8 43 15	4	.....	.....	1,040	Time at origin 8h., 41m.
		ePN	8 43 23	7	.....	.....	.....	
		eS_E	8 45 10	.....	.....	.....	.....	
		eS_N	8 45 12	.....	.....	.....	.....	
		L_E	8 45 32	20	.....	.....	.....	
		L_N	8 45 39	18	.....	.....	.....	
		M_E	8 46 15	18	870	.....	.....	
		M_N	8 46 43	16	.....	1,070	.....	
		C	8 48 ..	10	.....	.....	.....	
		F_N	9 23 ..	.....	.....	.....	.....	
		F_E	9 34 ..	6	.....	.....	.....	
6	.....	eP_E	12 07 09	4	.....	.....	.....	Not far distant. No discount M. N not in good adjustment.
		eP_N	12 07 24	.....	.....	.....	.....	
		eL_E	12 07 45	.....	10	.....	.....	
		eL_N	12 08 02	.....	.....	10	.....	
		F	12 28 ..	4	.....	.....	.....	

Arizona. *Tucson. Magnetic Observatory.* U. S. Coast and Geodetic Survey. William H. Cullum.

Lat. 32° 14′ 48″ N.; long., 110° 50′ 06″ W. Elevation, 769.6 meters.

Instruments: Two Bosch-Omori, 10 and 12 kg.

Instrumental constants.. E: $V = 10$, $T_0 = 14$; N: $V = 10$, $T_0 = 19$

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	eL_E	10 21 00	.....	.....	.....	.....	Nothing on N.
		M_E	10 25 20	19	10	.....	.....	
		C_E	10 31 ..	.....	.....	.....	.....	
		F_E	11 07 ..	.....	.....	.....	.....	
4	.....	eP_N	11 58 00	4	.....	.....	.....	Time marking clock out of order. Times are based on the assumption of a uniform rate of the driving clocks.
		eP_E	11 59 23	.....	.....	.....	.....	
		eS_N	12 08 22	.....	.....	.....	.....	
		eL_E	12 16 ..	.....	.....	.....	.....	
		eL_N	12 24 ..	.....	.....	.....	.....	
		M_E	12 26 34	15	60	.....	.....	
		M_N	12 26 35	.....	.....	40	.....	
		C_N	12 35 ..	.....	.....	.....	.....	
		C_E	12 50 ..	15	.....	.....	.....	
		F_N	13 24 ..	.....	.....	.....	.....	
		F_E	14 07 ..	13	.....	.....	.....	
6	.....	P_E	8 45 52	3	.....	.....	.....	Do.
		P_N	8 46 50	3	.....	.....	.....	
		S_E	8 49 53	12	.....	.....	.....	
		S_N	8 50 55	.....	.....	.....	.....	
		eL_E	8 51 15	25	.....	.....	.....	
		eL_N	8 54 10	.....	.....	.....	.....	
		M_N	8 55 30	17	.....	340	.....	
		M_E	8 55 35	12	600	.....	.....	
		C_N	8 57 ..	.....	.....	.....	.....	
		C_E	9 00 ..	11	.....	.....	.....	
		F_N	9 11 ..	.....	.....	.....	.....	
		F_E	9 42 ..	8	.....	.....	.....	
9	.....	eP_E	19 21 20	.....	.....	.....	.....	
		eL_E	19 43 15	.....	.....	.....	.....	
		M_E	19 46 10	16	10	.....	.....	
		F_E	20 39 ..	.....	.....	.....	.....	
23	.....	eP_E	19 54 35	.....	.....	.....	.....	
		eL_E	19 59 28	.....	.....	.....	.....	
		M_E	20 00 43	12	50	.....	.....	
		F_E	20 14 ..	.....	.....	.....	.....	

California. *Berkeley. University of California.*

Lat., 37° 52′ 16″ N.; long., 122° 15′ 37″ W. Elevation, 85.4 meters.

(*See* Bulletin of the Seismographic Stations, University of California.)

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks
California. *Mount Hamilton. Lick Observatory.* Lat., 37° 20′ 24″ N.; long., 121° 38′ 34″ W. Elevation, 1,281.7 meters. (*See* Bulletin of the Seismographic Stations, University of California.)								
California. *Point Loma. Raja Yoga College.* F. J. Dick. Lat., 32° 43′ 03″ N.; long., 117° 15′ 10″ W. Elevation, 91.4 meters. Instrument: Two-component, C. D. West seismoscope.								
1918. Dec. 4	.....	.....	*H. m. s.*	*Sec.*	μ 200	μ 200	*km.*	Tremors during 24 hours preceding 16h. 00m. on date given.
California. *Santa Clara. University of Santa Clara.* J. S. Ricard, S. J. Lat., 37° 20′ 36″ N.; long., 121° 57′ 03″ W. Elevation, 27.43 meters. (*See* record of the Seismographic Station, University of Santa Clara.)								
Colorado. *Denver. Sacred Heart College.* Earthquake Station. A.W. Forstall, S. J. Lat., 39° 40′ 36″ N.; long., 104° 56′ 54″ W. Elevation, 1,655 meters. Instrument: Wiechert 80 kg., astatic, horizontal pendulum.								
1918. Dec. 2	.....	L_E....	*H. m. s.* 14 30 ..	*Sec.*	μ	μ	*km.*	Distinct activity on E–W.
		F_E....	19	.....	.....	.....	.....	
4	.....	L.....	11 37 ..	20	*500	*500	.....	Very regular sinusoidal. Time and beginning somewhat doubtful.
		F.....	11 46 ..	.....	.....	.....	.....	
6	.....	P.....	8 43 ..	.....	*4,000	*3,500	.....	First preliminaries of large amplitude. Second preliminaries not easily discernible.
		S.....	8 ? ?	.....	.....	.....	.....	
		L.....	8 49 ..	5–6	*6,000	*6,000	.....	
		M_E....	8 50 ..	6	*7,500	.....	.....	
		M_N....	8 51 ..	6	.....	*7,500	.....	
		C.....	8 53 ..	.....	.....	.....	.....	
		F.....	9 02 ..	.....	.....	.....	.....	
21	.....	L_N....	12 26 ..	.....	.....	.....	.....	Distinct but very small waves, stronger on N–S.
		F_N....	12 34 ..	.....	.....	.....	.....	
30–31	.....	.....	.....	.....	.....	.....	.....	Activity at intervals.
31	.....	P.....	3 33 ..	20	.....	*6,800	.....	First preliminaries on N–S have large amplitude. Second preliminaries not discernible.
		L.....	3 36 ..	.....	.....	.....	.....	
		F.....	3 53 ..	.....	.....	.....	.....	

* Trace amplitude.

District of Columbia. *Washington. U. S. Weather Bureau.

Lat., 38° 54′ 12″ N.; long., 77° 03′ 03″ W. Elevation, 21 meters.

Instrument: Marvin (vertical pendulum), undamped. Mechanical registration.

	V	T_0
Instrumental constants..	110	6.4

1918. Dec. 1	.....	i.....	*H. m. s.* 2 59 33	*Sec.*	μ	μ	*km.* .....
		eL....	3 30 ..	.....	.....	.....	.....
		L.....	3 33 ..	16	.....	.....	.....
		F.....	4 00 ..	.....	.....	.....	.....
2	.....	iP.....	9 55 21	.....	.....	.....	4,080
		S.....	10 01 35	.....	.....	.....	.....
		L.....	10 05 40	24	.....	.....	.....
		F.....	11 00 ..	.....	.....	.....	.....
4	.....	P.....	11 58 24	.....	.....	.....	7,030
		S.....	12 06 55	.....	.....	.....	.....
		L.....	12 16 ..	24	.....	.....	.....
		L.....	12 29 ..	18	.....	.....	.....
		L.....	12 44 ..	16	.....	.....	.....
		L.....	14 28 ..	26	.....	.....	.....
		F.....	15 00 ..	.....	.....	.....	.....

Date	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington*—Continued.								
1918. Dec. 6	.....	iP.....	*H. m. s.* 8 48 10	*Sec.*	μ	μ	*Km.* 3,940	
		S.....	8 53 54	.....	.....	.....	.....	
		L?....	8 57 40	.....	.....	.....	.....	
		M.....	9 02 ..	.....	*75,000	*75,000	.....	
		F.....	9 55 ..	.....	.....	.....	.....	
6	.....	e.....	12 20 ..	.....	.....	.....	.....	Followed by very heavy microseisms.
		M.....	12 22 40	.....	*7,000	.....	.....	
		F?....	12 45 ..	.....	.....	.....	.....	
9	.....	e.....	18 41 ..	.....	.....	.....	.....	
		L.....	18 44 30	16	.....	.....	.....	
		F.....	19 00 ..	.....	.....	.....	.....	
9	.....	P?....	19 03 34	.....	.....	.....	.....	
		S?....	19 17 36	.....	.....	.....	.....	
		eL?...	19 27 35	.....	.....	.....	.....	
		L?....	19 31 30	16	.....	.....	.....	
		F?....	20 25 ..	.....	.....	.....	.....	
21	.....	P.....	9 32 20	.....	.....	.....	3,040	
		S.....	9 37 52	.....	.....	.....	.....	
		L?....	9 47 ..	.....	.....	.....	.....	
		F.....	9 55 ..	.....	.....	.....	.....	
23	.....	e.....	19 58 25	.....	.....	.....	.....	
		eL....	19 59 20	.....	.....	.....	.....	
		F.....	20 20 ..	.....	.....	.....	.....	

* Trace amplitude.

District of Columbia. *Washington. Georgetown University.* F. A. Tondorf, S. J.

Lat., 38° 54′ 25″ N.; long., 77° 04′ 24″ W. Elevation, 42.4 meters. Subsoil: Decayed diorite.

Instruments: Wiechert 200 kg. astatic horizontal pendulums, 80 kg. vertical.

		V	T_0	ε
Instrumental constants..	E	165	5.4	0
	N	143	5.2	0
	Z	*80*	*3.0*	*0*

1918. Dec. 1	.....	e.....	*H. m. s.* 2 59 30	*Sec.*	μ	μ	*km.*	Heavy microseisms. No distinct Main.
		eLΓ...	3 30 06	.....	.....	.....	.....	
		L_E....	3 33 12	16	.....	.....	.....	
		L_N....	3 33 37	16	.....	.....	.....	
		F.....	3 55 ..	.....	.....	.....	.....	
2	.....	P.....	9 55 21	.....	.....	.....	.....	Do.
		S_N....	10 01 38	.....	.....	.....	.....	
		S_E....	10 01 39	.....	.....	.....	.....	
		eL....	10 07 00	32	.....	.....	.....	
		F.....	10 56 ..	.....	.....	.....	.....	
			VERTICAL.		*Az.*			
		eP....	*9 55 29*	.....	.....	.....	.....	*S doubtful.*
		eL....	*10 06 48*	24	.....	.....	.....	
		F.....	*10 40* ..	.....	.....	.....	.....	
4	.....	P_E....	11 58 22	.....	.....	.....	.....	Heavy microseisms. F difficult.
		P_N....	11 58 27	.....	.....	.....	.....	
		S.....	12 07 07	.....	.....	.....	.....	
		eL....	12 17 42	20	.....	.....	.....	
		M_E....	12 19 54	23	*1,000	.....	.....	
		M_N....	12 30 00	20	.....	*1,300	.....	
		F.....	15 ca	.....	.....	.....	.....	
6	.....	e_N....	7 41 10	.....	.....	.....	.....	Microseisms. Difficult.
			Set post-ea.					
6	.....	iP.....	8 48 11	.....	.....	.....	.....	E–W needle off.
		S.....	8 53 57	.....	.....	.....	.....	
		eL_E...	8 57 24	7	.....	.....	.....	
		eL_N...	8 57 30	7	.....	.....	.....	
		M_E....	9 00 44	8	*42,000+	.....	.....	
		M_N....	9 00 51	8	.....	*30,500	.....	
		F.....	10ca	.....	.....	.....	.....	
			VERTICAL.		*Az.*			
		P.....	*8 47 54*	.....	.....	.....	.....	
		eS....	*8 53 29*	.....	.....	.....	.....	
		eL....	*8 56 30*	*11*	.....	.....	.....	
		M.....	*9 00 48*	*7*	.....	*11,300	.....	
		F.....	*10 20* ..	.....	.....	.....	.....	
6	.....	e_E....	12 13 45	.....	.....	.....	.....	Gram difficult, very heavy microseisms. F surely after 12h, 30m.
		e_N....	12 14 29	.....	.....	.....	.....	
		S?.....	12 21 34	.....	.....	.....	.....	
		i?.....	12 22 21	.....	.....	.....	.....	
		F?....	12 ? ?	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington*—Continued.								
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 9	.....	e	18 41 26	.....	.....	.....	.....	Very heavy microseisms. F lost in following 'quake.
		eL_E?	18 43 42	16	.....	.....	.....	
		eL_N?	18 44 24	13	.....	.....	.....	
		L_E	18 46 ..	16	.....	.....	.....	
		F?	19 ? ?	.....	.....	.....	.....	
9	.....	eL	19 26 ..	.....	.....	.....	.....	Very heavy microseisms. F difficult.
		L_E	19 30 30	14	.....	.....	.....	
		L_N	19 30 42	16	.....	.....	.....	
		L_N	19 34 ..	19	.....	.....	.....	
		L_E	19 35 ..	19	.....	.....	.....	
		F	20 20 ..	.....	.....	.....	.....	
21	.....	P_N	9 32 21	.....	.....	.....	.....	
		P_E	9 32 24	.....	.....	.....	.....	
		i_N	9 32 56	.....	.....	.....	.....	
		S_E	9 38 23	.....	.....	.....	.....	
		eL	9 42 06	11	.....	.....	.....	
		L	9 47 ..	14	.....	.....	.....	
		F	10 02 ..	.....	.....	.....	.....	
23	.....	e	19 57 04	.....	.....	.....	.....	Heavy microseisms. S very doubtful.
		S_N?	19 58 38	.....	.....	.....	.....	
		S_E?	19 58 40	.....	.....	.....	.....	
		F	20 10 ..	.....	.....	.....	.....	

Hawaii. *Honolulu. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Frank Neuman.

Lat., 21° 19′ 12″ N.; long., 158° 03′ 48″ W. Elevation, 15.2 meters.

Instrument: Milne seismograph of the Seismological Committee of the British Association.

Instrument constant $\frac{T_0}{}$ .. 18.5

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 1	.....	eP	3 12 00	.....	.....	.....	.....	
		L	3 25 00	.....	.....	.....	.....	
		M	3 28 30	.....	*200	.....	.....	
		F	4 00 ..	.....	.....	.....	.....	
2	.....	P	10 12 18	19	.....	.....	.....	Irregular tremors continued to 12h. 28m.
		S	10 15 54	20	.....	.....	.....	
		L	10 20 00	.....	.....	.....	.....	
		M	10 23 12	.....	*200	.....	.....	
		C	10 25 ..	.....	.....	.....	.....	
		F	? ? ?	.....	.....	.....	.....	
2	.....	eL	10 47 30	.....	.....	.....	.....	Do.
		M	10 52 24	20	*300	.....	.....	
		C	10 54 ..	.....	.....	.....	.....	
		F	? ? ?	.....	.....	.....	.....	
2	.....	eL	12 05 00	.....	.....	.....	.....	
		M	12 23 30	18	*100	.....	.....	
		F	12 48 ..	.....	.....	.....	.....	
3	.....	eL	23 31 12	.....	.....	.....	.....	
		M	23 39 30	18	*50	.....	.....	
		C	23 44 ..	.....	.....	.....	.....	
4	.....	F	0 33 ..	.....	.....	.....	.....	
4	.....	P	12 03 24	20	.....	.....	.....	Preceeded and followed by five hours of microseisms.
		S	12 13 12	17	.....	.....	.....	
		L	12 33 42	25	.....	.....	.....	
		M	12 41 18	17	*8,400	.....	.....	
		C	12 47 ..	18	.....	.....	.....	
		F	15 postea	.....	.....	.....	.....	
6	.....	e	7 33 12	.....	.....	.....	.....	
		L	8 07 12	.....	.....	.....	.....	
		M	8 14 00	.....	*600	.....	.....	
		C	8 16 ..	.....	.....	.....	.....	
		F	8 20 ..	.....	.....	.....	.....	
6	.....	eP	8 48 24	18	.....	.....	.....	
		iS	8 54 06	16	.....	.....	.....	
		eL	8 58 30	.....	.....	.....	.....	
		M	9 03 00	18	*2,400	.....	.....	
		C	9 07 ..	19	.....	.....	.....	
		F	10 32 ..	.....	.....	.....	.....	
6	.....	e	11 49 30	.....	.....	.....	.....	
		M	11 52 00	.....	*100	.....	.....	
		F	12 27 ..	.....	.....	.....	.....	
9	.....	e	1 38 42	.....	.....	.....	.....	
		M	1 43 ..	.....	*100	.....	.....	
		C	1 47 ..	.....	.....	.....	.....	
		F	2 04 ..	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
District of Columbia. *Washington*—Continued.								
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 9	.....	e	4 32 00	.....	.....	.....	.....	
		M	4 44 00	19	$100	.....	.....	
		C	4 46 ..	19	.....	.....	.....	
		F	4 59 ..	.....	.....	.....	.....	
9	.....	eP	18 16 18	.....	.....	.....	.....	Tremors continue to next 'quake.
		iS	18 18 24	.....	.....	.....	.....	
		eL	18 21 42	.....	.....	.....	.....	
		M	18 25 00	.....	*700	.....	.....	
		F	19 ? ?	.....	.....	.....	.....	
9	.....	eP	19 01 00	.....	.....	.....	.....	
		iS	19 06 48	.....	.....	.....	.....	
		eL	19 12 00	.....	.....	.....	.....	
		M	19 16 00	.....	*1,200	.....	.....	
		C	19 20 ..	.....	.....	.....	.....	
		F	20 13 ..	.....	.....	.....	.....	
10	.....	e	17 33 30	22	.....	.....	.....	
		M	17 39 12	.....	*200	.....	.....	
		C	17 42 ..	.....	.....	.....	.....	
		F	17 55 ..	.....	.....	.....	.....	
23	.....	eP	20 14 54	20	.....	.....	.....	Pendulum not entirely free from Dec. 16-23.
		eL	20 16 00	20	.....	.....	.....	
		M	20 19 30	18	*100	.....	.....	
		C	20 22 ..	18	.....	.....	.....	
		F	21 22 ..	.....	.....	.....	.....	
25	.....	P	10 29 12	18	.....	.....	.....	
		iS	10 36 24	20	.....	.....	.....	
		eL	10 49 12	.....	.....	.....	.....	
		M	10 52 54	.....	*300	.....	.....	
		C	11 01 ..	.....	.....	.....	.....	
		F	11 23 ..	.....	.....	.....	.....	
30	.....	eP	7 36 24	20	.....	.....	.....	
		eL	7 42 48	21	.....	.....	.....	
		M	7 48 00	17	*200	.....	.....	
		C	7 50 ..	18	.....	.....	.....	
		F	8 21 ..	.....	.....	.....	.....	

*Trace amplitude.

Kansas. *Lawrence. University of Kansas.* Department of Physics and Astronomy. F. E. Kester.

Lat., 38° 57′ 30″ N.; long., 95° 14′ 58″ W. Elevation, 301.1 meters.

Instrument: Wiechert.

Instrumental constants .. $\begin{cases} & V & T_0 & \epsilon \\ E & 177 & 3.4 & 4:1 \\ N & 205 & 3.4 & 4:1 \end{cases}$

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 4	.....	eP	11 58 41	.....	.....	.....	.....	
		eS_E	12 07 43	.....	.....	.....	.....	
		eS_E?	12 07 51	.....	.....	.....	.....	
		L_E	12 16 22	.....	.....	.....	.....	
		L_N?	12 16 53	.....	.....	.....	.....	
		M_E	12 16 58	.....	7.9	.....	.....	
		M_N	12 17 10	.....	.....	2.0	.....	
		F_E	14 45 ..	.....	.....	.....	.....	
		F_N	14 51 ..	.....	.....	.....	.....	
6	.....	P_E	8 46 24	.....	.....	.....	.....	
		P_N	8 46 26	.....	.....	.....	.....	
			8 46 27	.....	− 7.6	− 3.9	.....	
		M	8 46 30	4-6	+27.1	+15.6	.....	
		S_E	8 50 49	.....	.....	.....	.....	
		S_N	8 50 51	.....	.....	.....	.....	
		L_E	8 53 57	.....	.....	.....	.....	
		L_N?	8 54 04	.....	.....	.....	.....	
		M_E	8 54 32	4-5	+55.4	.....	.....	
		M_N	8 54 39	4-5	.....	−48.3	.....	
		F	10 15 ..	.....	.....	.....	.....	
6	.....	P_E	12 08 17	.....	.....	.....	.....	
		P_N	12 08 19	.....	.....	.....	.....	
			12 08 20	.....	+25.4	−19.5	.....	
		S_N?	12 12 48	.....	.....	.....	.....	
		S_E?	12 12 52	.....	.....	.....	.....	
		L_E	12 15 55	.....	.....	.....	.....	
		L_N	12 15 57	.....	.....	.....	.....	
		F	12 46 ..	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
								Maryland. *Cheltenham. Magnetic Observatory.* U. S. Coast and Geodetic Survey. George Hartnell.
								Lat. 38° 44′ 00″ N.; long., 76° 50′ 30″ W. Elevation, 71.6 meters.
								Instruments: Two Bosch-Omori, 10 and 12 kg.
								Instrumental constants. V: E 10, N 10; T_0: E 15, N 15
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 1	.....	eL_E	3 32 20	.....	.....	.....	.....	
		eL_N	3 33 30	.....	.....	.....	.....	
		M_N	3 34 10	15	.....	10	.....	
		M_E	3 34 20	16	10	.....	.....	
		F	3 46 ..	15	.....	.....	.....	
2	.....	eP	9 55 36	3	.....	.....	.....	Long waves not well defined.
		S_N	10 01 46	9	.....	.....	.....	
		S_E	10 01 55	9	.....	.....	.....	
		M_N	10 02 00	.....	.....	30	.....	
		M_E	10 07 20	.....	20	.....	.....	
		F_N	10 31 ..	9	.....	.....	.....	
		F_E	10 38 ..	9	.....	.....	.....	
4	.....	P	11 58 30	3	.....	.....	.....	
		S_E	12 07 00	.....	.....	.....	.....	
		eS_N	12 07 57	.....	.....	.....	.....	
		eL_N	12 25 45	.....	.....	.....	.....	
		eL_E	12 28 40	.....	.....	.....	.....	
		M_N	12 30 10	18	.....	410	.....	
		M_E	12 30 30	.....	50	.....	.....	Actual maximum (100 μ) at 12h., 08m., 25s.
		C	12 33 ..	.....	.....	.....	.....	
		F	13 47 ..	.....	.....	.....	.....	
6	.....	P	8 48 16	3	.....	.....	4,020	Time at origin 8h., 41m.
		S	8 54 04	8	.....	.....	.....	
		eL_N	8 58 40	.....	.....	.....	.....	
		eL_E	9 00 06	.....	.....	.....	.....	
		M_N	9 00 40	.....	.....	600	.....	
		M_E	9 01 02	.....	550	.....	.....	
		C	9 06 ..	.....	.....	.....	.....	
		F	9 35 ..	8	.....	.....	.....	
6	.....	eP_N	12 21 28	3	.....	.....	.....	
		eP_E	12 22 08	3	.....	.....	.....	
		S	12 22 40	3	.....	.....	.....	
		eL_E	12 25 ..	.....	.....	.....	.....	
		M_E	12 25 45	6	20	.....	.....	Actual maximum (40 μ) at 12h., 22m., 42s. on both N. and E.
		F	12 31 ..	.....	.....	.....	.....	
9	.....	eL_E	18 44 30	.....	.....	.....	.....	
		eL_N	18 44 50	.....	.....	.....	.....	
		M_N	18 48 ..	18	.....	.....	.....	
		F	18 49 ..	.....	.....	.....	.....	
9	.....	eL_N	19 28 25	.....	.....	.....	.....	
		eL_E	19 30 55	.....	.....	.....	.....	
		M_E	19 36 15	15	10	.....	.....	
		M_N	19 37 10	15	.....	10	.....	
		F	19 52 ..	.....	.....	.....	.....	
23	.....	eP_N	19 54 51	.....	.....	.....	.....	
		eP_E	19 55 46	.....	.....	.....	.....	
		L_N	19 59 24	.....	.....	.....	.....	
		L_E	19 59 54	.....	.....	.....	.....	
		M_E	20 00 18	11	20	.....	.....	
		M_N	20 00 18	13	20	.....	.....	
		C	20 01 ..	8	.....	.....	.....	
		F	20 13 ..	8	.....	.....	.....	
								Massachusetts. *Cambridge. Harvard University Seismographic Station.* J. B. Woodworth.
								Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.
								Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration)
								Instrumental constants. V: E 80, N 50; T_0: E 23, N 25; ε: E 0, N 4:1
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 1	.....	*O*	*2 postea*	.....	.....	.....	.....	
		i_N?	2 59 44	6	.....	.....	.....	Isolated waves. Continuous record from e_N.
		i_N?	3 00 40	7	.....	.....	.....	
		e_N	3 12 51	6	.....	.....	.....	
		L_N	3 24 52	20	.....	.....	.....	
		L_N	3 27 06	28	.....	.....	.....	
		L_N	3 28 20	18	.....	.....	.....	
		L_N	4 04 30	14	.....	.....	.....	
		F?	4 05 50	.....	.....	.....	.....	
1	.....	L?	5 48 49	8	.....	.....	.....	
		F?	5 49 45	.....	.....	.....	.....	

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
								Massachusetts. *Cambridge*—Continued.
1918.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Dec. 2	.....	*O*	*9 47 48*	.....	.....	.....	4,220	N uncertain.
		P_E?	9 55 21	.....	.....	.....	.....	
		P_N?	9 55 24	.....	.....	.....	.....	
		S_N?	10 00 56	22	.....	.....	.....	
		S_E	10 01 21	.....	.....	.....	.....	
		eL_E	10 04 22	16	.....	.....	.....	
		F_E	11 30 ..	.....	.....	.....	.....	
4	.....	O_N	*11 47 57*	.....	.....	.....	7,550	67° 57′. Northern Chile.
		O_E	*11 47 50*	.....	.....	.....	7,650	68° 45′.
		P_N	11 58 35	.....	.....	.....	.....	Break in records changing sheets from 13h., 06m. to 14h., 24m.
		P_E	11 58 53	.....	.....	.....	.....	
		S_N	12 07 32	19	.....	.....	.....	
		S_E	12 07 55	14	.....	.....	.....	
		eL_N	12, 22 33	44	.....	.....	.....	F masked by microseisms.
		M_N	12 24 58	25	.....	.....	.....	
		M_N	12 27 40	18	.....	*3,500	.....	
		M_E	12 28 46	19	*3,500	.....	.....	
		M_E	12 30 49	18	*4,375	.....	.....	
		to	12 34 ..	.....	.....	.....	.....	
		M_N	12 31 05	20	.....	*40,000	.....	
		M_N	12 33 23	20	.....	.....	.....	Undamped.
		M_N	12 35 51	20	.....	.....	.....	
		M_E	12 36 02	18	*5,000	.....	.....	
		M_N	12 37 24	20	.....	*41,000	.....	Do.
		C_E	12 40 ..	.....	.....	.....	.....	
		C_N	12 46 ..	.....	.....	.....	.....	
		.....	.. .. ..	.....	.....	.....	.....	
		CL	14 25 22	16	.....	.....	.....	
		.....	14 27 31	24	.....	.....	.....	
		.....	14 38 41	20	.....	.....	.....	
		.....	14 43 16	.....	.....	.....	.....	
		.....	15 11 ..	22	.....	.....	.....	
		F_E?	15 52 ..	.....	.....	.....	.....	
4	.....	L_N	18 16 04	20	.....	.....	.....	May not be seismic: not shown on E among microseisms.
		L_N	18 19 10	20	.....	.....	.....	
		to	18 23 ..	.....	.....	.....	.....	
6	.....	*O*	*8 40 54*	.....	.....	.....	3,930	35° 22′.
		iP_E	8 48 07	.....	.....	.....	.....	N undamped, stylus thrown off sheet at 9h. 02m.
		S_E	8 53 50	.....	.....	.....	.....	
		eL_N	8 59 44	44	.....	.....	.....	
		eL_E	9 01 17	40	.....	.....	.....	
		M_E	9 02 04	15	*19,000	.....	.....	
		M_E	9 03 ..	.....	.....	.....	.....	
		M_E	9 06 28	.....	*13,700	.....	.....	
		F_E	9 54 ..	.....	.....	.....	.....	
6	.....	*O*	*18 postea*	.....	.....	.....	2,000–3,000	e and F in microseisms.
		e_N	12 18 43	.....	.....	.....	.....	
		e_E	12 22 14	.....	.....	.....	.....	
		eL_N	12 22 16	40	.....	.....	.....	
		L_E	12 23 51	4–6	.....	.....	.....	
		M_E	12 24 13	.....	.....	.....	.....	
		F?	12 38 ..	.....	.....	.....	.....	
9	.....	*O*	*18 postea*	.....	.....	.....	.....	e lost in heavy microseisms. Times of phases somewhat uncertain, clock pendulum out of order. F merged in next 'quake.
		e?	18 21 ..	.....	.....	.....	.....	
		eL_N	18 34 05	40	.....	.....	.....	
		L_E	18 40 05	15	.....	.....	.....	
		M_N	18 44 08	19	.....	.....	.....	
		M_N	18 45 05	.....	.....	.....	.....	
		F	19 ? ?	.....	.....	.....	.....	
9	.....	e_N?	19 20 28	.....	.....	.....	.....	e confused with earlier 'quake and microseisms. F in heavy microseisms.
		eL_N	19 23 58	40	.....	.....	.....	
		L_E	19 25 04	12	.....	.....	.....	
		M_E	19 31 21	16	*800	.....	.....	
		M_E	19 34 37	16	*1,000	.....	.....	
		M_N	19 34 53	.....	.....	.....	.....	
		F?	21 43 ..	.....	.....	.....	.....	
14	.....	*O*	*19*	.....	.....	.....	.....	
		eL_E	19 40 ..	16	.....	.....	.....	
		L	19 41 30	20	.....	.....	.....	
		to	19 50 ..	.....	.....	.....	.....	
21	.....	*O*?	*9 21 12*	.....	.....	.....	4,170?	△ and *O* from L–S. Pendulum steps north.
		i_N	9 32 41	.....	.....	.....	.....	
		e_N	9 33 22	2	.....	.....	.....	Pendulum steps north. But microseisms of 6 seconds period were running at the time.
		i_N	9 33 28	.....	.....	.....	.....	
		S_N?	9 34 39	6	.....	.....	.....	
		e_E	9 36 37	6	.....	.....	.....	
		eL_N	9 36?39	13	.....	.....	.....	
		e_E	9 40 46	6	.....	.....	.....	
		e_N	9 42 34	6	.....	.....	.....	
		L_E	9 42 53	8	.....	.....	.....	
		L_N	9 43 15	10	.....	.....	.....	
		L_N	9 47 48	10	.....	.....	.....	
		F	9 55 ..	.....	.....	.....	.....	
25	.....	*O*	*6 14 15*	.....	.....	.....	27	Explosion of powder mill, Maynard, Mass. E damped 1.5/1; N 0/1. Loud noise heard, shook house near by.
		P_N	6 14 19	.....	.....	.....	.....	
		P_E	6 14 19	.....	.....	.....	.....	
		M_E	6 14 21½	0.41	*500	.....	.....	
		M_N	6 14 22	.....	.....	.....	.....	
		C_E	6 14 28	.....	.....	.....	.....	
		F_E	6 14 33	.....	.....	.....	.....	
		F_N	6 14 41	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Missouri. *Saint Louis. St. Louis University.* Geophysical Observatory. J. B. Goesse, S. J.

Lat., 38° 38′ 15″ N.; long., 90° 13′ 58″ W. Elevation, 160.4 meters. Foundation: 12 feet of tough clay over limestone of Mississippi system, about 300 feet thick.

Instrument: Wiechert 80 kg. astatic, horizontal pendulum.

Instrumental constants.. V 80, T_0 7, ε 5:1

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	eP.....	9 56 48	.....	.....	.....	5,200	
		eS.....	10 03 42	.....	.....	.....	.....	
		eL.....	10 06 06	.....	.....	.....	.....	
		M.....	10 09 06	30	.....	*1,000	.....	
		F.....	11 05 ..	.....	.....	.....	.....	
4	.....	iP_E...	11 58 42	.....	.....	.....	9,600	Reported from Chili. N–S well defined. E–W very undefined and irregular.
		eS.....	12 08 24	.....	.....	*4,000	.....	
		L.....	12 19 00?	.....	.....	.....	.....	
		L.....	12 26 00	18	.....	.....	.....	
		L.....	12 29 54	18	.....	*3,000	.....	
		F.....	13 26 ..	.....	.....	.....	.....	
4	.....	eL_E...	13 48 06	.....	.....	.....	.....	Record on E–W well defined, N–S hardly noticeable; hence it is believed that this disturbance is quite distinct from the one above. P and S lost changing record. F lost in microseisms, which continued all day.
		P.....	13 ? ?	.....	.....	.....	.....	
		S.....	13 ? ?	.....	.....	.....	.....	
		F.....	14	.....	.....	.....	.....	
6	.....	iP_E...	8 47 00	.....	.....	.....	3,200	Both E and N undamped.
		eS_E...	8 51 48	.....	.....	.....	.....	
		S_N....	8 52 00	.....	.....	.....	.....	
		L_N....	8 55 36	.....	.....	.....	.....	
		L_E....	8 55 54	.....	.....	.....	.....	
		M_N....	8 56 18	6	.....	*46,000	.....	
		M_E....	8 56 30	9	*21,000	.....	.....	
		F.....	10 16 ..	.....	.....	.....	.....	
6	.....	e_N.....	12 10 54	.....	.....	.....	.....	
		e_N.....	12 17 36	.....	.....	.....	.....	
		i_E.....	12 17 48	.....	.....	.....	.....	
		e_E.....	12 20 12	.....	.....	.....	.....	
		F.....	? ? ?	.....	.....	.....	.....	
9	.....	e_E.....	18 22 00	.....	.....	.....	.....	
		eL.....	18 35 36	.....	.....	.....	.....	
		F.....	? ? ?	.....	.....	.....	.....	
9	.....	iP_E...	19 03 00	.....	.....	.....	.....	
		e.....	19 11 09	.....	.....	.....	.....	
		L.....	19 26 00	.....	.....	.....	.....	
		F.....	21 ? ?	.....	.....	.....	.....	

* Trace amplitude.

New York. *Buffalo. Canisius College.* John A. Curtin, S. J.

Lat., 42° 53′ 02″ N.; long., 78° 52′ 40″ W. Elevation, 190.5 meters.

Instrument: Wiechert 80 kg. horizontal.

Instrumental constants.. V 80, T_0 7, ε 5:1

(Report for December, 1918, not received.)

New York. *Fordham. Fordham University.* Daniel H. Sullivan, S. J.

Lat., 40° 51′ 46″ N.; long., 73° 53′ 08″ W. Elevation, 29.3 meters.

Instrument: Wiechert, 80 kg.

Instrumental constants.. {E: V 72, T_0 5.0, ε 0; N: V 72, T_0 5.0, ε 0}

New York. *Ithaca. Cornell University.* Heinrich Ries.

Lat., 42° 36′ 58″ N.; long., 76° 29′ 09″ W. Elevation, 242.6 meters.

Instruments: Two Bosch-Omori, 25 kg., horizontal pendulums (mechanical registration).

Instrumental constants.. {E: V 13, T_0 22, ε 4:1; N: V 14, T_0 25, ε 4:1}

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	eP_E...	9 51 19	3	.....	.....	.....	Microseisms. Time clock erratic.
		eP_N...	9 51 23	3	.....	.....	.....	
		S_E....	9 57 47	15	.....	.....	.....	
		S_N....	9 57 48	17	.....	.....	.....	
		L_N....	10 03 02	21	.....	.....	.....	
		L_E....	10 03 10	16	.....	.....	.....	
		M_N....	10 03 55	15	.....	*600	.....	
		F_E....	10 51 ..	.....	.....	.....	.....	
4	.....	eP_N...	11 59 47	3	.....	.....	.....	
		eP_E...	12 00 25	3	.....	.....	.....	
		eS_N...	12 08 43	10	.....	.....	.....	
		eS_E...	12 08 50	9	.....	.....	.....	
		i_E.....	12 09 45	15	*1,000	.....	.....	
		M_N....	12 34 10	19	.....	*1,500	.....	
		M_E....	12 34 20	18	$1,300	.....	.....	
		F.....	15	.....	.....	.....	.....	
6	.....	P_E....	8 48 33	3	.....	.....	.....	Time clock not in good order.
		P_N....	8 4 358	3	.....	.....	.....	
		eS_N...	8 54 02	6	.....	.....	.....	
		eS_E...	8 54 03	7	.....	.....	.....	
		M.....	9 00 33	15	*4,200	*7,000	.....	
		M_E....	9 01 09	10	*4,000	.....	.....	
		M_N....	9 01 18	9	.....	*6,000	.....	
		F.....	9 59 ..	.....	.....	.....	.....	
6	.....	e.....	12 19 ..	5	.....	.....	.....	Microseisms.
		M.....	12 22 15	5	*500	.....	.....	
		L_E....	12 24 45	11	.....	.....	.....	
		F.....	12 31 ..	.....	.....	.....	.....	
9	.....	eL_E...	18 40 ..	25	.....	.....	.....	
		F_E....	19 02 ..	.....	.....	.....	.....	
9	.....	eP?...	19 12 ..	4	.....	.....	.....	Time marker not working; times estimated.
		eL?...	19 27 15	13	.....	.....	.....	
		L_E....	19 30 ..	14	.....	.....	.....	
		F_E....	20 11 ..	.....	.....	.....	.....	
21	.....	eP_N...	9 33 26	3	.....	.....	.....	
		S_E....	9 39 14	6	.....	.....	.....	
		e.....	9 42 30	5	.....	.....	.....	
		L_E....	9 44 15	26	.....	.....	.....	
		F_E....	10 00 ..	.....	.....	.....	.....	
23	.....	e_E.....	19 54 15	6	.....	.....	.....	
		L_E....	19 59 11	25	.....	.....	.....	
		F.....	20 22 ..	.....	.....	.....	.....	

*Trace amplitude.

Panama Canal. *Balboa Heights.* Governor, Panama Canal.

Lat., 8° 57′ 39″ N.; long., 79° 33′ 29″ W. Elevation, 27.6 meters.

Instruments: Two Bosch-Omori, 100 kg.

Instrumental constants.. V 35, T_0 20

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	P.....	9 54 46	.....	.....	.....	.....	Faint trace.
		F.....	10 28 00	.....	.....	.....	.....	
4	.....	P_E....	11 55 08	.....	.....	.....	2,320	
		P_N....	11 55 16	.....	.....	.....	.....	
		L_E....	12 01 42	.....	.....	.....	.....	
		L_N....	12 02 08	.....	.....	.....	.....	
		M_E....	12 04 06	.....	*4,000	.....	.....	
		M_N....	12 13 56	.....	.....	$3,000	.....	
		F_N....	13 27 32	.....	.....	.....	.....	
		F_E....	13 30 00	.....	.....	.....	.....	
4	.....	P_E....	15 27 36	.....	.....	.....	90	
		P_N....	15 27 56	.....	.....	.....	.....	
		L_E....	15 28 24	.....	.....	.....	.....	
		M_E....	15 28 30	.....	*800	.....	.....	
		L_N....	15 28 34	.....	.....	.....	.....	
		M_N....	15 28 40	.....	.....	*1,800	.....	
		F_E....	15 32 00	.....	.....	.....	.....	
		F_N....	15 34 00	.....	.....	.....	.....	

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Panama Canal. *Balboa Heights*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 4	.....	$P_{.....}$	17 15 04	.....	*300	*500	.....	Faint trace.
		F.....	17 19 00	.....	.....	.....	.....	
6	.....	P.....	8 51 00	.....	.....	.....	.....	Do.
		F.....	8 58 00	.....	.....	.....	.....	
11	.....	P_N.....	17 48 50	.....	.....	.....	735	
		P_E.....	17 49 14	.....	.....	.....	.....	
		L_E.....	17 50 50	.....	.....	.....	.....	
		M_E.....	17 50 54	.....	*1,000	.....	.....	
		L_N.....	17 52 26	.....	.....	.....	.....	
		M_N.....	17 52 36	.....	.....	*1,000	.....	
		F.....	18 00 00	.....	.....	.....	.....	
12	.....	P.....	8 21 00	.....	.....	.....	.....	Very indistinct trace.
		F.....	8 22 00	.....	.....	.....	.....	
21	.....	P_E.....	9 27 46	.....	.....	.....	1,000	
		P_N.....	9 27 49	.....	.....	.....	.....	
		L_N.....	9 29 53	.....	.....	.....	.....	
		L_E.....	9 29 54	.....	.....	.....	.....	
		M_E.....	9 29 55	.....	*3,000	.....	.....	
		M_N.....	9 29 57	.....	.....	$1,500	.....	
		F.....	9 42 00	.....	.....	.....	.....	
23	.....	P.....	19 47 00	.....	.....	.....	.....	Slight disturbance.
		F.....	20 02 00	.....	.....	.....	.....	
27	.....	P.....	8 27 00	.....	.....	.....	.....	Do.
		F.....	8 31 00	.....	.....	.....	.....	

* Trace amplitude.

Porto Rico. *Vieques. Magnetic Observatory.* U. S. Coast and Geodetic Survey. Wallace M. Hill.

Lat., 18° 09′ N.; long., 65° 27′ W. Elevation, 19.8 meters.

Instruments: Two Bosch-Omori.

Instrumental constants.. {E V 10 T_0 17; N 10 20}

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	P_E.....	9 52 44	4	.....	.....	.....	
		P_N.....	9 52 50	3	.....	.....	.....	
		S?.....	9 56 52	.....	.....	.....	.....	
		M_E.....	9 57 50	.....	20	.....	.....	
		M_N.....	9 58 14	28	.....	300	.....	
		C.....	10 00 ..	8	.....	.....	.....	
		F.....	10 50 ..	.....	.....	.....	.....	
4	.....	eP_N.....	11 55 59	3	.....	.....	.....	Phases not well defined and difficult to correlate. Paper of N changed at 12h., 57m. and nothing appears on the new sheet.
		eP_E.....	11 56 12	3	.....	.....	.....	
		eS_E.....	12 03 34	13	.....	.....	.....	
		eS_N.....	12 03 52	8	.....	.....	.....	
		$?_E$.....	12 06 40	24	.....	.....	.....	
		$?_N$.....	12 06 56	14	.....	.....	.....	
		M_E.....	12 07 12	26	420	.....	.....	
		eL_E.....	12 10 30	24	.....	.....	.....	
		eL_N.....	12 12 20	30	.....	.....	.....	
		M_E.....	12 14 30	22	240	.....	.....	
		M_N.....	12 19 01	18	.....	1,200	.....	
		C.....	12 25 ..	16	.....	.....	.....	
		F_N.....	12 57 ?	15	.....	.....	.....	
		F_E.....	14 02 ..	16	.....	.....	.....	
6	.....	P_N.....	8 51 32	4	.....	.....	.....	P and S very faint.
		S_E.....	8 59 02	8	.....	.....	.....	
		S_N.....	8 59 08	8	.....	.....	.....	
		eL_E.....	9 09 11	24	.....	.....	.....	
		eL_N.....	9 09 50	22	.....	.....	.....	
		M_N.....	9 16 04	20	.....	20	.....	
		M_E.....	9 16 31	20	20	.....	.....	
		C.....	9 20 ..	17	.....	.....	.....	
		F.....	9 34 ..	.....	.....	.....	.....	
21	.....	e_N.....	9 29 54	5	.....	.....	.....	No definite phases.
		e_E.....	9 30 25	.....	.....	.....	.....	
		M_N.....	9 35 03	8	.....	10	.....	
		M_E.....	9 37 09	12	10	.....	.....	
		F_N.....	9 42 ..	.....	.....	.....	.....	
		F_E.....	9 50 ..	.....	.....	.....	.....	
23	.....	P_E.....	19 49 31	5	.....	.....	.....	
		P_N.....	19 49 40	5	.....	.....	.....	
		S_N?...	19 55 50	.....	.....	.....	.....	
		eL_E.....	20 00 11	10	.....	.....	.....	
		eL_N.....	20 00 20	12	.....	.....	.....	
		M_E.....	20 00 25	10	10	.....	.....	
		F_N.....	20 05 ..	.....	.....	.....	.....	
		F_E.....	20 08 ..	(end)	.....	.....	.....	

Vermont. *Northfield. U. S. Weather Bureau.* Wm. A. Shaw.

Lat., 44° 10′ N.; long., 72° 41′ W. Elevation, 256 meters.

Instruments: Two Bosch-Omori, mechanical registration.

Instrumental constants.. {E V 10 T_0 15; N 10 16}

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 2	.....	e.....	9 55 27	.....	.....	.....	.....	
		S.....	10 01 44	.....	.....	.....	.....	
		L.....	10 05 00	20	.....	.....	.....	
		L.....	10 21 00	14	.....	.....	.....	
		F.....	10 40 ..	.....	.....	.....	.....	
4	.....	P.....	11 58 54	.....	.....	.....	.....	
		S.....	12 08 05	.....	.....	.....	.....	
		eL.....	12 16 20	.....	.....	.....	.....	
		L.....	12 34 00	16	.....	.....	.....	
		F.....	13 20 ..	.....	.....	.....	.....	
6	.....	P.....	8 47 57	.....	.....	.....	.....	
		S.....	8 53 55	.....	.....	.....	.....	
		eL.....	8 59 ?	.....	.....	.....	.....	
		M_E.....	9 04 ..	.....	*6,000	.....	.....	
		F.....	9 40 ..	.....	.....	.....	.....	
6	.....	e_N.....	12 21 ..	.....	.....	.....	.....	Phases uncertain.
		F.....	12 35 ..	.....	.....	.....	.....	

* Trace amplitude.

Canada. *Ottawa. Dominion Astronomical Observatory.* Earthquake Station. Otto Klotz.

Lat., 45° 23′ 38″ N.; long., 75° 42′ 57″ W. Elevation, 83 meters.

Instruments: Two Bosch photographic horizontal pendulums, one Spindler & Hoyer 80 kg. vertical seismograph.

Instrumental constants. V 120 T_0 26

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 1	.....	i.....	2 58 56	.....	.....	.....	.....	
		eL_E?..	3 14 48	.....	.....	.....	.....	
		L.....	3 20 ..	32	.....	.....	.....	
		L.....	3 28 ..	18	.....	.....	.....	
		L.....	3 38 ..	14	.....	.....	.....	
		F.....	3 55 ..	.....	.....	.....	.....	
2	.....	*O*.....	*9 47 30*	.....	.....	.....	4,800	
		iP.....	9 55 45	.....	.....	.....	.....	
		iS.....	10 02 16	.....	.....	.....	.....	
		eL.....	10 05 30	21	.....	.....	.....	
		L.....	10 09 ..	21	.....	.....	.....	
		L.....	10 17 ..	14	.....	.....	.....	
		L.....	10 32 ..	.....	.....	.....	.....	
		F.....	11 10 ..	.....	.....	.....	.....	
4	.....	*O*.....	*11 47 43*	.....	.....	.....	8,000	
		eP.....	11 59 04	.....	.....	.....	.....	
		eS.....	12 08 24	.....	.....	.....	.....	
		eL.....	12 19 18	34	.....	.....	.....	
		L.....	12 30 ..	19	.....	.....	.....	
		L.....	12 36 ..	17	.....	.....	.....	
		L.....	12 50 ..	17	.....	.....	.....	
		L.....	13 00 ..	16	.....	.....	.....	
		L.....	13 15 ..	18	.....	.....	.....	
		L.....	13 33 ..	18	.....	.....	.....	
		L.....	13 50 ..	15	.....	.....	.....	
		L.....	14 05 ..	15	.....	.....	.....	
		L.....	14 15 ..	15	.....	.....	.....	
		$L_{Intrepl}$..	14 16 ..	30	.....	.....	.....	
		L_{trepl}..	14 25 ..	23	.....	.....	.....	
		F.....	15 10 ..	.....	.....	.....	.....	
6	.....	i.....	7 42 28	.....	.....	.....	.....	
		eL_N...	8 05 48	18	.....	.....	.....	
		to	8 17 ..	.....	.....	.....	.....	
6	.....	*O*.....	*8 40 58*	.....	.....	.....	3,650	
		P.....	8 47 50	.....	.....	.....	.....	
		S.....	8 53 16	.....	.....	.....	.....	
		eL.....	8 55 ..	?	.....	.....	.....	
		M.....	9 00 ..	10	100	200	.....	
		L.....	9 20 ..	10	.....	.....	.....	
		F.....	9 55 ..	.....	.....	.....	.....	
		SASKATOON RECORD.						
		O.....	*8 40 56*	.....	.....	.....	1,460	
		P.....	8 44 05	.....	.....	.....	.....	
		S.....	8 46 38	.....	.....	.....	.....	
		L.....	8 47 36	.....	.....	.....	.....	

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Ottawa*—Continued.								
		HALIFAX RECORD.						
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
		O	*8 40 57*				4,560	N–S component off the sheet during maximum.
		P_N	8 48 55					
		S	8 55 13					Above value for △ indicate an epicenter in northern British Columbia.
6		e_E?	12 13 44					
		e_E	12 15 ..					
		eL?	12 19 36					
		M	12 22 ..		15ca	35ca		
		F	12 35 ..					
9		e	18 30 30					F merged in next 'quake.
		eL?	18 35 30					
		L	18 39 ..	21				
		L	18 43 ..	15				
		L	18 52 ..	15				
		F	? ? ?					
9		e	? ? ?					e lost in microseisms and Coda of 'quake above.
		eL?	19 25 ..					
		L	19 29 ..	15				
		L	19 45 ..	13				
		L	20 01 ..	13				
		F	20 40 ..					
19		eL_E?..	20 40 ..					Very small amplitude, barely visible.
		to	20 45 ..					
21		*O*	*9 24 51*				4,920	
		P_N	9 33 14					
		S	9 39 52					
		eL_E	9 45 30	24				
		L_N	9 51 ..	12				
		F	10 05 ..					
23		e_N?..	19 56 ..					
		eL	20 00 ..	21?				
		L	20 10 ..	14?				
		F	20 35 ..					
25		e	10 59 40					L barely visible.
		eL	11 24 ..	21				
		to	11 32 ..					
		F	11 40 ..					
26		eL_N	8 49 ..	21				Barely visible.
		to	8 54 ..					

Canada. *Toronto. Dominion Meteorological Service.*

Lat., 43° 40′ 01″ N.; long., 79° 23′ 54″ W. Elevation, 113.7 meters. Subsoil: Sand and clay.

Instrument: Milne horizontal pendulum, North. In the meridian.

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.50″.

1918.			*H. m. s*	*Sec.*	μ	μ	*km.*	
Dec. 1		P?	3 14 24?					F lost in microseisms.
		e	3 21 24					
		L	3 22 24					
		eL	3 32 24					
		eL	3 37 42					
		M	3 42 48		*700			
		L?	4 36 42					
		F	? ? ?					
2		P	9 56 00				5,220	S waves came in abruptly and of large amplitude. F lost in microseisms.
		iS	10 02 54					
		L	10 05 36					
		L	10 08 42					
		M	10 09 48		*1,300			
		F	? ? ?					
3								Microseisms during night hours when other stations record a small 'quake.
4		eP	11 59 36				7,850	Chili. Well-defined record. S waves of large amplitude.
		e	12 07 36					
		iS	12 08 48					
		iL	12 15 48					
		L	12 19 36					
		iL	12 30 48					
		iL	12 37 12					
		M	12 38 54		*4,800			
		iL	12 44 06					
		eL	12 56 12					
		eL	13 39 18					
		eL	14 55 12					
		F	15 21 36					

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Canada. *Toronto*—Continued.								
1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
4		eL	18 22 12					
		M	18 23 12		*100			
		F	18 41 00					
6		L	7 47 24		*100			Microseisms masked other phases.
6		P	8 47 54				3,520	Epicenter 49° 32′ N, 127° W. P poorly defined and microseisms may have masked beginning of S. F lost in microseisms.
		e	8 50 18					
		S	8 53 12					
		L	8 55 00					
		iL	8 58 06					
		M	9 01 24		*6,800			
		L	9 18 42					
		F	? ? ?					
6		L	12 18 30					F lost in microseisms.
		L	12 20 06					
		M	12 21 42		*400			
		F	? ? ?					
9		eL	5 20 36					Gradual thickening.
		M	5 23 24		*200			
		F	5 38 18					
9		L	18 35 12					F merged in following 'quake.
		L	18 39 48					
		eL	18 43 06					
		M	18 44 12		*300			
		F	19					
9		L	19 31 36					Earlier phases lost; light off at 19h., 21m.
		M?	19 33 06		*2,200			
		eL	19 39 36					
		F	20 35 12					
14		L	19 02 48		*50			
		F	19 19 18					
14		L	19 37 54					Gradual thickening.
		eL	19 43 36					
		M	19 50 18		*200			
		F	20 02 ..					
19		L?	20 24 ..					Heavy microseisms.
21		S	9 39 42					F lost in microseisms.
		eL	9 47 30					
		M	9 49 36		*700			
		F	? ? ?					
23		e?	19 46 00				4,120?	Microseisms going on during first phases.
		e?	19 51 18					
		P	19 52 48					
		S	19 58 42					
		eL	20 00 18					
		eL	20 01 00					
		M	20 02 12		*1,000			
		F	20 37 06					
25		L	11 24 12					Microseisms masked phases.
		L	11 31 24		*200			
		L	11 32 24					
		F	? ? ?					
26								Microseisms going on when other stations record a small 'quake.

* Trace amplitude.

Canada. *Victoria, B. C. Dominion Meteorological Service.*

Lat., 48° 24′ N.; long., 123° 19′ W. Elevation, 67.7 meters. Subsoil: Rock.

Instrument: Wiechert, vertical; Milne horizontal pendulum, North. In the meridian

Instrumental constant.. T_0 18. Pillar deviation: 1 mm. swing of boom=0.54″.

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 1		P	3 13 09?				2,760	Alaska?
		S	3 17 34					
		L	3 24 27					
		M	3 30 31		*300			
		F	4 04 18					
2		P	10 07 30?				3,240	Aleutian Islands? Times of P and S very doubtful.
		S	10 12 30?					
		L	10 22 00					
		M	10 38 00		*1,200			
		F	12 55 00					

* Trace amplitude.

TABLE 2.—*Instrumental reports, October, 1918*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
			Canada. *Toronto*—Continued.					
1918			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Dec. 4	.....	M.....	0 00 19	.....	*50	.....	.....	
		F.....	0 07 12	.....	.....	.....	.....	
4	.....	P.....	12 00 56	.....	.....	.....	9,520	Northern Chili (Copiapo).
		S.....	12 11 14	.....	.....	.....	.....	
		S.....	12 11 32	.....	.....	.....	.....	
		L.....	12 28 51	.....	.....	.....	.....	
		M.....	12 42 59	.....	*2,600	.....	.....	
		F.....	15 37 42	.....	.....	.....	.....	
			VERTICAL.	*Az.*				
		P.....	*12 00 44*	.....	.....	.....	*8,710*	Do.
		S.....	*12 10 40*	.....	.....	.....	.....	
		L.....	*12 19 00*	.....	.....	.....	.....	
		M.....	*12 41 00*	.....	.....	9	.....	
		F.....	*13 26 00*	.....	.....	.....	.....	
4	.....	P.....	18 24 08	.....	.....	.....	890	
		S.....	18 26 07	.....	.....	.....	.....	
		L.....	18 29 46	.....	.....	.....	.....	
		M.....	18 32 04	.....	*300	.....	.....	
		F.....	18 52 54	.....	.....	.....	.....	
6	.....	P.....	8 04 18	.....	.....	.....	.....	
		M.....	8 12 20	.....	*200	.....	.....	
		F.....	? ? ?	.....	.....	.....	.....	
6	.....	P.....	8 41 39	.....	.....	.....	336?	Probably off west coast of Vancouver Island and northwest of Estevan.
		S. & L.	8 42 27	.....	.....	.....	.....	
		M.....	8 43 15	.....	*17,000	.....	.....	
		eL.....	9 24 34	.....	.....	.....	.....	
		F.....	10 34 25	.....	.....	.....	.....	
			VERTICAL.	*Az.*				
		P.....	*8 41 44*	*2*	.....	.....	*520*	Do.
		S. & L.	*8 42 28*	*4*	.....	.....	.....	
		M.....	*8 42 40*	*8*	.....	*490*	.....	
		F.....	*9 29 00*	.....	.....	.....	.....	
6	.....	P.....	12 02 51	.....	.....	.....	220	Probably off west coast of Vancouver Island and south of Estevan
		S. & L.	12 03 21	.....	.....	.....	.....	
		M.....	12 04 20	.....	*1,500	.....	.....	
		F.....	12 24 10	.....	.....	.....	.....	
			VERTICAL.	*Az.*				
		P.....	*12 03 32*	*2*	.....	.....	*270*	Do.
		S. & L.	*12 04 08*	*4*	.....	.....	.....	
		M.....	*12 04 24*	*4*	.....	*71*	.....	
		F.....	*12 16 00*	.....	.....	.....	.....	
9	.....	P.....	4 51 47	.....	.....	.....	4,140?	
		S.....	4 56 42	.....	.....	.....	.....	
		L.....	5 04 08	.....	.....	.....	.....	
		M.....	5 05 37	.....	*200	.....	.....	
		F.....	5 11 34	.....	.....	.....	.....	
9	.....	P.....	18 10 04?	.....	.....	.....	1,400?	
		S.....	18 12 31	.....	.....	.....	.....	
		L.....	18 15 58	.....	.....	.....	.....	
		M.....	18 25 18	.....	*400	.....	.....	
		F.....	18 49 53	.....	.....	.....	.....	
9	.....	L.....	19 04 41	.....	.....	.....	.....	
		M.....	19 16 35	.....	*500	.....	.....	
		F.....	20 02 42	.....	.....	.....	.....	
11	.....	.....	9	.....	.....	.....	.....	Estevan reports 2 local tremors. Not recorded at Victoria.
14	.....	L.....	18 59 31?	.....	.....	.....	.....	
		M.....	19 03 29	.....	*200	.....	.....	
		M.....	19 30 16	.....	*400	.....	.....	May be a dual 'quake.
		F.....	19 39 11	.....	.....	.....	.....	
19	.....	L.....	20 11 00	.....	.....	.....	.....	No cut-off for first phases.
		M.....	20 20 21	.....	*200	.....	.....	
		F.....	20 28 13	.....	.....	.....	.....	
21	.....	P.....	9 38 33?	.....	.....	.....	2,770?	
		S.....	9 42 59	.....	.....	.....	.....	
		L.....	9 52 19	.....	.....	.....	.....	
		M.....	10 03 09	.....	*200	.....	.....	
		F.....	10 28 14	.....	.....	.....	.....	
23	.....	M ?...	20 12 12	.....	*1,000	.....	.....	First phases lost at cut-off.
		F.....	20 24 30	.....	.....	.....	.....	
25	.....	L.....	10 50 04	.....	.....	.....	.....	
		M.....	11 16 13	.....	*400	.....	.....	
		F.....	11 31 57?	.....	.....	.....	.....	

* Trace amplitude.

TABLE 3.—*Late seismological reports (instrumental).*

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.

Massachusetts. *Cambridge. Harvard University Seismographic Station* J. B. Woodworth.

Lat., 42° 22′ 36″ N.; long., 71° 06′ 59″ W. Elevation, 5.4 meters. Foundation: Glacial sand over clay.

Instruments: Two Bosch-Omori 100 kg. horizontal pendulums (mechanical registration).

Instrumental constants..		*V*	T_0	ε
	E	80	23	0
	N	50	25	4:1

1918.			*H. m. s.*	*Sec.*	μ	μ	*km.*	
Nov. 3	.....	*O*.....	*11 48 36*	.....	.....	.....	7,950	71° 55′.
		S_E.....	12 09 12	6	.....	.....	.....	
		eL_E...	12 23 28	28	.....	.....	.....	Amplitude E very small; not recognized on N undamped.
		L.....	12 30 06	20	.....	.....	.....	
		L.....	12 40 41	20				Press reports 'quake in Hawaii at 11h., 33m. p. m. and outbreak of Kilauea.
		L.....	12 44 51	15	.....	.....	.....	
		L.....	13 00 06	15	.....	.....	.....	
		F.....	13 02 24	.....	.....	.....	.....	
4	.....	L_E?...	18 34 51	15–12	.....	.....	.....	Not assuredly seismic; among microseisms of 8 sec. period.
		F?.....	18 36 45	.....	.....	.....	.....	
5	.....	*O*?.....	*22 30 05*	.....	.....	.....	6,580	59° 22′ of arc.
		S_N?...	22 46 27	10	.....	.....	.....	N undamped.
		eL_N?..	22 58 57	38				L_E 23h., 00m., 04s. to 23h. 05m., 46s. period.
		L_N....	23 00 00	20	.....	.....	.....	
		M_N....	23 02 36	20	.....	.....	.....	18–16 sec.
		C_N?...	23 04 16	15	.....	.....	.....	
		F_N?...	23 16 ..	.....	.....	.....	.....	
8	.....	*O*.....	*4 38 21*	.....	.....	.....	8,750	78° 45′ of arc.
		P_N....	4 50 21	2	.....	.....	.....	
		P_E....	4 51 08	.....	.....	.....	.....	
		S_E....	5 00 19	6	.....	.....	.....	
		S_N....	5 00 48	10	.....	.....	.....	
		i_E....	5 01 41	.....	.....	.....	.....	
		e_E....	5 02 50	13	.....	.....	.....	
		e_E....	5 03 19	.....	.....	.....	.....	
		eL_N...	5 16 ..	.....	.....	.....	.....	Short waves superposed.
		eL_E...	5 16 01	44	.....	.....	.....	Do.
		L_E....	5 17 15	35	.....	.....	.....	
		M_E....	5 18 56	21	*8,000	.....	.....	A 235.
		M_E....	5 25 19	22	*7,000	.....	.....	
		M_E....	5 27 35	23	*11,500	.....	.....	
		M_E....	5 31 25	21	*17,500	.....	.....	A 515.
		M_E....	5 34 35	.....	*12,500	.....	.....	
		M_E....	5 36 49	20	*9,750	.....	.....	
		M_E....	5 37 43	17	*18,750	.....	.....	A 1,000.
		C_E....	5 38 25	14	.....	.....	.....	
		F.....	7 22 ..	.....	.....	.....	.....	
12	.....	*O*.....	*21 44 24*	.....	.....	.....	2,680	23° 56′ of arc.
		iP_N...	21 49 40	4	.....	.....	.....	N undamped, E damped by magnet, N starts before E. Microseism mask certain phases. Compare record Oct. 11, 1918, △ 2,690, *O* 14*h.*, 14*m.*, 14*s.*
		iP_{rep1}.	21 49 52	.....	.....	.....	.....	
		eP_{Erep1}	21 50 09	2	.....	.....	.....	
		S_N....	21 53 59	14	.....	.....	.....	
		S_E?....	21 54 09	6	.....	.....	.....	
		eL_N...	21 55 45	22–30	.....	.....	.....	
		eL_E...	21 55 33	24	.....	.....	.....	
		M_E....	21 57 57	16	*1,500	.....	.....	
		M_E....	21 59 43	16	*1,250	.....	.....	
		C_N....	22 00 30	.....	.....	.....	.....	
		F_E....	22 43 ..	.....	.....	.....	.....	
		F_N....	22 56 ..	.....	.....	.....	.....	
18	.....	*O*.....	*18 41 55*	.....	.....	.....	16,000	*O* computed from Riverview, Sydney, N. S. W., gives △ 3,470 km., giving epicenter lat. 10° S., long. 130° E.; reported as felt at Port Darwin. i from W. L_N at 20h., 28m. is evidently M of a second 'quake coming from same epicenter about 35m. after the first M on return of P reflected from anticentrum. M_N does not accord with $L_{rep.}$ A similar group of lenticular M waves appears about 35m. after M_1 in the record of Jan. 1, 1919; *0, 3h. plus.*
		iP_E....	18 59 35	.....	.....	.....	.....	
		eP_N....	19 00 46	.....	.....	.....	.....	
		P_{Erepx}.	19 01 18	10	*1,000	.....	.....	
		P_{Nrepx}.	19 01 30	.....	.....	*1,000	.....	
		P_{Nrep1}.	19 04 25	12	.....	*5,000	.....	
		P_{Erep1}.	19 05 01	8	*3,500	.....	.....	
		iS_N....	19 13 18	9	.....	.....	.....	
		S_{rep1}..	19 23 05	14	.....	.....	.....	
		S_{rep2}..	19 29 16	.....	*5,750	.....	.....	
		i_N.....	19 32 56	.....	.....	*7,300	.....	
		i_N.....	19 40 36	18	.....	*9,000	.....	
		eL_N...	19 51 06	.....	.....	.....	.....	
		M_N....	19 54 05	.....	.....	.....	.....	
		M_N....	19 57 22	.....	.....	*5,700	.....	
		M_N....	20 06 04	.....	.....	.....	.....	
		M_N....	20 13 46	.....	.....	.....	.....	
		to	20 15 36	.....	.....	.....	.....	
		L_N....	20 28 ..	.....	.....	.....	.....	
		M_N....	20 29 24	.....	.....	.....	.....	
		F_N....	21 17 ..	.....	.....	.....	.....	

* Trace amplitude.

TABLE 3.—*Late seismological reports (instrumental)*—Continued.

Date.	Character.	Phase.	Time.	Period. T.	Amplitude. A_E	Amplitude. A_N	Distance.	Remarks.
Massachusetts. *Cambridge*—Continued.								
1918.			*H. m. s.*	*Sec.*	μ	μ	*Km.*	
Nov. 23	.....	*O*....	*22 52 11*	.....	.....	.....	10,550	94° 57′. △ and *O* from L_N–S_E. N much masked by microseisms.
		e_E....	23 09 31	3	.....	.....	.....	
		i_E....	23 09 51	6	.....	.....	.....	
		S_E....	23 17 02	6	.....	.....	.....	
		i_N....	23 26 34	.....	.....	.....	.....	
		i_E?...	23 26 57	8	.....	.....	.....	
		eL_E...	23 34 40	24	.....	.....	.....	
		eL_N...	23 38 29	28	.....	.....	.....	
		L_E....	23 39 20	36	.....	.....	.....	
		L_E....	23 43 49	24	.....	.....	.....	
		L_E....	23 50 30	16	.....	.....	.....	
24	.....	L_E....	0 03 10	24	.....	.....	.....	
		L_E....	0 07 29	24	.....	.....	.....	
		L_E....	0 10 16	20	.....	.....	.....	
		to	0 51 ..	.....	.....	.....	.....	
		L_{rept}..	0 57 50	16	.....	.....	.....	
		F_E....	1 05 ..	.....	.....	.....	.....	
30	.....	*O*?....	*6 28 13*	.....	.....	.....	11,970	? 107° 44′ from eL–S? P and S masked by microseisms.
		S_E?....	6 55 06	6	.....	.....	.....	
		eL_E...	7 21 22	26	.....	.....	.....	
		L_E....	7 23 39	27	.....	.....	.....	
		L_E....	7 24 16	20	.....	.....	.....	
		L_E....	7 26 45	16	.....	.....	.....	
		L_E....	7 28 03	.....	.....	.....	.....	A increased slightly.
		to	7 30 07	14	.....	.....	.....	
		L_N....	7 28 45	20–16	.....	.....	.....	
		L_E....	7 31 51	14–12	.....	.....	.....	
		F_E....	7 49 ..	.....	.....	.....	.....	

* Trace amplitude.

SEISMOLOGICAL DISPATCHES.[1]

Santiago, Chile, Dec. 4, 1918.

An earthquake has occurred in Northern Chile. In the towns of Copiapo and Vallener important damages were caused. In other localities damage of minor importance resulted.

Reports received here say that the earthquake destroyed Vallener, and that it wrecked 10 per cent of the buildings at Copiapo. Several deaths occurred in Copiapo, where many persons are homeless. (Assoc. Pr.)

Vancouver, British Columbia, Dec. 6, 1918.

This city was shaken violently by an earth tremor at 12:45 this morning. The tremors, which appeared to be from north to south, were felt for two minutes. A distinct rumbling was noticeable. Occupants of tall buildings were especially affected by the disturbance, many being seized with nausea.

The shock was felt in all parts of the city, many persons being awakened by the shaking of furniture and tumbling of dishes. (Assoc. Pr.)

Victoria, British Columbia, Dec. 6, 1918.

A pronounced earthquake of several seconds' duration was felt here at 12:45 o'clock this morning. Houses shook and windows rattled all over the city. Island points in the immediate vicinity also reported noticing the disturbance. (Assoc. Pr.)

Seattle, Washington, Dec. 6, 1918.

What was believed to be an earth disturbance was felt in Seattle at 12:45 o'clock this morning. The tremor shook buildings in the downtown district. (Assoc. Pr.)

EARTHQUAKES FELT IN THE UNITED STATES DURING 1918.

[Consult also Chart XI (XLV–122) in this issue.]

W. J. HUMPHREYS,
Professor in Charge of Seismological Investigations.

[Dated: Weather Bureau, Washington, Feb. 4, 1919.]

During the year 1918, 127 separate earthquakes strong enough to be felt were reported from different parts of the continental United States, as listed in the accompanying Table 1, and graphically represented (a dot for each report on Chart XI (XLVI–111)) at the end of this issue of the Review.

[1] Reported by the organization indicated and collected by the seismological station, at Georgetown University, Washington, D. C.

Earthquakes of moderate intensities, V–VI (Rossi-Forel), accompanied by only slight damage or none at all, occurred in California on February 11, March 6, 8, 21, 30, April 7, 23, 29, May 1, 2, June 3, 6, 14, 22, July 15, August 20, October 14, November 19, 29; in Arizona on April 21, 28; in Virginia on April 10; in the State of Washington on June 21, December 6; in Tennessee on June 22, October 16; in Oklahoma on September 11; in Arkansas on October 4, 13; and in Utah on November 16. The Virginia earthquake was apparently central in the vicinity of Luray and was felt over most of Virginia, a portion of West Virginia, much of Maryland, the District of Columbia, and into Pennsylvania.

Earthquakes of intensity, VII–VIII, accompanied by only a very moderate amount of damage, such as the fall of chimneys, occurred in California on March 12, apparently central near Downieville; and in Maine on August 21, apparently central near South Paris.

An earthquake of intensity, IX–X, and accompanied by some destruction of property, occurred in California on April 21, when the entire business sections of Hemet and San Jacinto were destroyed. This shock was felt over southern California and Nevada, western New Mexico, and into Utah, and was apparently caused by a new slip in the San Jacinto Fault.

An earthquake of similar intensity occurred in New Mexico on May 28, causing an open break in the surface of the ground at Cerillos.

There remains to be mentioned the great earthquake, not shown on the chart, but given in the tables, which occurred in Porto Rico on October 11. A great tidal wave 2 miles wide swept inland a half mile at Aguadilla, rising to a height of 40 feet against the cliffs, destroying everything in its path, and drowning many people. Over 60 shocks were noted during the period from October 11 to November 12. The frequency diminished rapidly, as is usual, and had fallen to about one a day by the end of October.

TABLE 1.—*Places in the United States reporting earthquakes during 1918.*

[Consult also Chart XI (XLV–122) in this issue.]

Place.	Approximate latitude (north.)	Approximate longitude (west).	Number of quakes reported.	Place.	Approximate latitude (north.)	Approximate longitude (west).	Number of quakes reported.
ARIZONA.	° ′	° ′		CALIFORNIA.	° ′	° ′	
Aztec	32 49	113 28	1	Aguanga	33 27	116 55	2
Bouse	33 57	114 01	1	Arroyo Seco	34 07	118 11	1
Cibola	33 21	114 42	1	Bagdad	34 35	115 52	1
Crozier	35 24	113 40	1	Banning	33 55	116 53	1
Flagstaff	35 12	111 37	4	Barrett	32 42	116 41	3
Kingman	35 11	114 04	1	Barstow	34 54	117 02	1
Mohave City	35 02	114 38	1	Beaumont	33 55	117 00	3
Oatman	35 02	114 25	1	Big Bar	40 44	123 18	1
Parker	34 10	114 17	1	Bishop	37 23	118 24	3
Quartzite	33 40	114 11	1	Blythe	33 35	114 41	1
Salome	33 47	113 37	1	Bonita	32 39	117 03	2
Seligman	35 19	112 51	1	Boulder Creek	37 08	122 07	1
Somerton	32 35	114 43	1	Brawley	33 00	115 31	1
Truxton	35 18	113 36	1	Cabazon	33 55	116 47	1
Wellton	32 40	114 08	1	Cahuilla	33 32	116 45	10
Wenden	33 49	113 32	1	Calexico	32 41	115 30	27
Yucca	34 52	114 09	1	Claremont	34 06	117 43	2
Yuma	32 45	114 36	2	Corona	33 53	117 34	3
				Coulterville	37 43	120 13	1
ARKANSAS.				Downieville	39 34	120 50	2
				El Cajon	32 48	116 59	3
Bauxite	34 33	92 24	1	Escondido	33 07	117 06	3
Black Rock	36 08	91 02	2	Eureka	40 48	124 11	3
Brinkley	34 53	91 07	1	Fairmont	34 45	118 26	1
Carlisle	34 47	91 39	1	Fontana	34 06	117 27	1
England	34 32	91 52	1	Fort Bragg	39 25	123 47	1
Hardy	36 19	91 21	1	Fresno	36 43	119 49	1
Hoxie	36 03	90 55	1	Hemet	33 44	116 58	21
Jonesboro	35 51	90 39	1	Hollywood	34 06	118 20	1
Little Rock	34 45	92 06	1	Imperial	32 51	115 33	1
Lonoke	34 47	91 49	1	Indio	33 43	116 13	3
Pine Bluff	34 13	91 54	1	Julian	33 04	116 36	3
Pocahontas	36 15	90 56	1	Keeler	36 38	117 52	1
Scott	34 43	92 01	1	Laguna Beach	33 31	117 47	1
Searcy	35 15	91 39	1	Lakeport	39 03	122 56	1

TABLE 1.—*Places in the United States reporting earthquakes during 1918*—Continued.

Place.	Approximate latitude (north).	Approximate longitude (west).	Number of quakes reported.
CALIFORNIA—con.	° ′	° ′	
Lone Pine	36 37	118 02	3
Los Angeles	34 03	118 15	2
Mecca	33 34	116 05	2
Mesa Grande	33 10	116 46	6
Morgan Hill	37 08	121 38	2
Mt. Lowe	34 13	118 08	1
Mt. Wilson	34 13	118 04	3
Nellie	33 19	116 52	3
Newhall	34 23	118 33	1
North Fork	37 20	119 20	1
Ocean Park	34 01	118 30	1
Ojai	34 25	119 12	1
Paso Robles	35 37	120 42	1
Point Loma	32 43	117 15	2
Pomona	34 03	117 45	1
Redlands	34 03	117 11	1
Rialto	34 06	117 22	2
Riverside	33 59	117 23	2
Round Valley	37 25	118 46	1
Salinas	36 41	121 39	3
San Bernardino	34 06	117 18	2
San Bernardino Mt.	34 07	116 56	1
San Diego	32 43	117 10	4
San Diego (Camp Kearny)	32 56	117 10	2
San Jacinto	33 46	116 58	9
San Luis Obispo	35 18	120 39	1
San Miguel Island	34 02	120 20	1
Santa Ana	33 46	117 53	1
Santa Monica	34 02	118 30	4
Spreckels	36 38	121 36	1
Stanford University	37 25	122 10	1
Table Bluff	40 41	124 10	1
Valley Cnter	33 13	117 04	1
Venice	33 58	118 28	4
Victorville	34 32	117 18	2
Warner Springs	33 17	116 39	6
Whitewater	33 53	116 38	1
Whittier	33 58	118 04	1
Winchester	33 42	117 06	1
Workman Station	33 55	118 11	1
DISTRICT OF COLUMBIA.			
Washington	38 54	77 03	1
ILLINOIS.	° ′	° ′	
Anna	37 28	89 14	1
Cairo	37 00	89 10	2
MAINE.			
Bridgton	44 03	70 42	1
Calais	45 11	67 17	1
Cape Elizabeth	43 35	70 14	1
Duck Pond Lake	43 46	70 21	1
Eastport	44 54	66 59	1
Lewiston	44 05	70 12	1
Little Sebago Lake	43 53	70 24	1
Norway	44 12	70 32	1
South Paris	44 13	70 30	1
MARYLAND.			
Bagley	39 30	76 23	1
Baltimore	39 17	76 37	1
Chewsville	39 38	77 37	1
Clear Spring	39 37	77 55	1
College Park	38 58	76 55	1
Solomons	38 19	76 27	1
Takoma Park	38 58	77 01	1
Woodstock	39 19	76 32	1
MICHIGAN.			
Calumet	47 14	88 28	1
Morrice	42 51	84 11	1
MISSOURI.			
Hannibal	39 41	91 20	1
NEVADA.			
Winnemucca	40 58	117 43	1
NEW MEXICO.			
Albuquerque	35 06	106 39	1
Cerillos	35 27	106 07	1
Espanola	36 00	106 05	1
Estancia	34 49	106 04	1
Lamy	35 29	105 03	1
NEW MEXICO—continued.	° ′	° ′	
Las Vegas	35 35	105 14	1
Montoya	35 06	104 04	1
Moriarty	34 59	106 03	1
Pena Blanca	35 35	106 21	1
Porvenir	35 43	105 25	1
Santa Fe	35 41	105 57	1
Stanley	35 07	106 00	1
Valmora (Watrous)	35 47	104 59	1
Waldo	35 28	106 10	1
OKLAHOMA.			
El Reno	35 31	97 57	3
Fort Reno	35 33	98 02	2
Union City	35 23	97 57	3
Yukon	35 30	97 44	1
OREGON.			
Portland	45 32	122 41	1
PENNSYLVANIA.			
Colebrook	40 26	76 04	1
PORTO RICO.			
Aguadilla	18 26	67 09	60
Isabela	18 30	67 03	60
Mayaguez	18 12	67 09	1
San Juan	18 29	66 07	5
TENNESSEE.			
Clarksville	36 31	87 22	1
Clinton	36 05	84 08	1
Kingston	35 52	84 32	1
Knoxville	35 56	83 58	2
Lenoir City	35 47	84 17	1
Loudon	35 44	84 21	1
McGhee	35 35	84 14	1
Memphis	35 09	90 03	2
Philadelphia	35 41	84 25	1
Savannah	35 12	88 15	1
Sweetwater	35 36	84 29	1
Union City	36 26	89 04	1
UTAH.	° ′	° ′	
Clarkston	41 55	112 05	1
Milford	38 24	113 01	1
Tremonton	41 42	112 10	1
VIRGINIA.			
Buchanan	37 32	79 41	1
Columbia	37 45	78 13	1
Culpeper	38 29	77 58	1
Dale Enterprise	38 27	78 55	2
Danville	36 34	79 26	1
Gordonsville	38 09	78 11	1
Guinea	38 09	77 26	1
Harrisonburg	38 25	78 52	1
Luray	38 41	78 27	2
Lynchburg	37 25	79 09	1
New Canton	37 43	78 23	1
Norfolk	36 51	76 17	1
Orange	38 15	78 07	1
Rapidan	38 19	78 04	1
Richmond	37 32	77 27	1
Roanoke	37 16	79 56	1
Staunton	38 10	79 04	1
Suffolk	36 43	76 35	1
University	38 02	78 31	1
White Post	39 04	78 07	1
Williamsburg	37 16	76 43	1
Winchester	39 10	78 10	1
Woodstock	38 53	78 31	1
WASHINGTON.			
Longmire	46 46	121 50	1
North Fork Sauk River	48 06	121 22	1
Seattle	47 38	122 20	1
Walla Walla	46 02	118 20	1
White Bluff Prairie	47 40	117 35	1
WEST VIRGINIA.			
Buckhannon	38 59	80 15	1
Martinsburg	39 28	77 58	1

SECTION VI.—BIBLIOGRAPHY.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

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Una visita all'Osservatorio meteorologico dell'Università. Malta. 1916. cover-title, 7 p. 19 cm. (Estratto dalla Guida di Malta e Gozo di G. Muscat. Anno 1916.)

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Letture pireliometriche esguite nel periodo guigno, 1915–dicembre, 1917. Firenze. 1918. 2 v. tables. charts. diagr. 24 cm. (Pubblicazioni dell'Osservatorio Ximeniano dei P. P. Scolopi, Firenze. Num. 123 & 125.)

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Ewing, E. C.
A study of certain environmental factors and varietal differences influencing the fruiting of cotton. Agricultural college, Miss. 1918. 93 [2] p. 40 charts, 23 tables. 21½ cm. At head of title: Mississippi agricultural experiment station. Technical bulletin no. 8. [Discusses meteorological influences.]

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Fujiwhara, Sakuhei.
On the theory of the Lowitz's arc and allied phenomena. Tôkyô. [1918] diagrs. 26½ cm. (Reprinted from . . . Proceedings of the Tôkyô mathematico-physical society. 2d ser. Vol. 9, No. 21. p. 502–515.)

Gautier, Raoul & Rod, Ernest.
Moyennes de 10 à 20 ans pour les éléments météorologiques observés aux fortifications de Saint-Maurice, 1908–1917 et 1898–1917. Genève. 1918. 14 tables. 22½ cm. (Extrait des Archives des sciences physiques et naturelles. Volume 46. Septembre 1918. p. [151]–176.)
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The observer's handbook. Approved for the use of meteorological observers by the Meteorological office, the Royal meteorological society, the Scottish meteorological society, the British rainfall organization. Annual edition, 1918. London. 1918. xxviii, 139 p. plates. illus. tables. (part. fold.) 25 cm. M. O. 191. (1918.)

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Houk, Ivan E.
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Annual report of the meteorological and the seismological observations for the year 1917. Mizusawa. 1918. 2 p. l., 40 p., l. incl. tables. 30 cm. Final leaf in Japanese.

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Sul valore meccanico e fisico delle differenze e delle tendenze barometriche. charts. 24½ cm. (Estr. dagli Atti della Reale accademia delle scienze di Torino, vol. 53, p. [237]–244. Adunanza del 13 Gennaio 1918.)

RECENT PAPERS BEARING ON METEOROLOGY AND SEISMOLOGY.

C. FITZHUGH TALMAN, Professor in Charge of Library.

The following titles have been selected from the contents of the periodicals and serials recently received in the Library of the Weather Bureau. The titles selected are of papers and other communications bearing on meteorology and cognate branches of science. This is not a complete index of all the journals from which it has been compiled. It shows only the articles that appear to the compiler likely to be of particular interest in connection with the work of the Weather Bureau.

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Science. New York. v. 49. 1919.

MacCaughey, Vaughan. Tropical enervation. p. 44–46. (Jan. 10.)

Lovejoy, Frederick A., & Allen, Francis H. An uncommon ice formation. p. 119–120. (Jan. 31.)

Scientific American supplement. New York. v. 87. January 4, 1919.

McAdie, Alexander. Uniformity in aerographic records. The desirability of universal scientific units. p. 15–16. [Repr. Annals Harvard College Obsy.]

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Aichi, Keiichi. On the penetration of the periodic temperature waves into a substance, having no uniform constitution, especially into the soil. p. 527–541.

Nakamura, Saemontarô. Note on the Tsunamis. p. 548–555.

Archives des sciences physiques et naturelles. Genève. 4 période. v. 46. Octobre-novembre 1918.

Gautier, Raoul, & Rod, Ernest. Nouvelles moyennes pour les principaux éléments météorologiques de Genève de 1826 à 1915 ou 1917. p. 210–230.

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Platania, Giovanni. Osservazioni dei punti neutri della polarizzazione atmosferica. p. 84–88.

Bemporad, A. Studio dell'estinzione atmosferica per stelle di diversi tipi spettrali. p. 94–99.

SECTION VII.—WEATHER AND DATA FOR THE MONTH.

WEATHER FOR DECEMBER, 1918.

P. C. DAY, Climatologist and Chief of Division.

[Dated; Weather Bureau, Washington, Feb. 3, 1919]

PRESSURE AND WINDS.

The distribution of the mean atmospheric pressure over the United States and Canada, and the prevailing direction of the winds for December, 1918, are graphically shown on Chart VII, while the means at the several stations, with the departures from the normal, are shown in Tables I and III.

The average sea-level barometric pressure for the month was below the normal in the great central valleys and over the far Southwest, but elsewhere it was generally above normal. The minus departures were as a rule small; so, also, were the plus departures, save in the northeastern Canadian Provinces and the far Northwest where they were more pronounced. (A more detailed discussion of the pressure distribution during December will be found under "Forecasts and Warnings.")

The general distribution of the barometric pressure favored northwesterly to westerly winds in the coastal portion of the Atlantic States and in the Missouri Valley, and southerly to southwesterly in much of the Mississippi Valley and portions of the Lake region. Elsewhere variable winds prevailed.

TEMPERATURE.

During the first decade of December moderate temperature prevailed in most districts, although on the morning of the 2d heavy to killing frosts were reported as far south as Mississippi, Alabama, and extreme northwestern Florida. Unusually warm weather for the season continued generally east of the Rocky Mountains until near the middle of the third decade, when much colder weather overspread the Plains region and central valleys, the line of zero temperature extending over the Plains States southward to Oklahoma, and that of freezing to the central Gulf coast. During the following few days it continued cold over the southern Rocky Mountain region, but slightly warmer weather prevailed over most eastern districts. At the close of the month a severe cold wave was advancing from the Northwest over the Plains States, with temperatures ranging from −30° F. in North Dakota to 0° F. in central Kansas.

The month as a whole was warmer than normal over nearly all districts east of the Rocky Mountains and in the far Northwest, and in a number of the Eastern States it was one of the warmest Decembers of record. In portions of the Ohio, middle Mississippi, and Missouri valleys, the monthly averages were nearly 10 degrees above the normal, and over much of the remaining area to eastward of the Rocky Mountains the averages were from 3 to 6 degrees above normal. On the other hand the month was persistently cold in the central and southern Rocky Mountain and Plateau States and generally to the westward, the averages for the month ranging from 3 to 6 degrees below the normal.

PRECIPITATION.

The first week of December was marked by generally fair weather, except that showers were frequent in the far Northwest, some rain fell during the first day or two in the Southeastern States, and rain or snow was frequent from the upper Mississippi Valley eastward, the snowfall being considerable in northern Michigan, and quite heavy in portions of northern New York and southern New England. Shortly after the middle of the first decade rain set in over the Pacific Coast States and the Colorado River basin, and by the end of the decade rain or snow had fallen over an extensive area eastward to the Ohio Valley. During the first half of the second decade precipitation was general and frequent from Oklahoma, Texas, and the Mississippi Valley eastward, occurring mostly in the form of rain. After a few days of relatively fair weather rain or snow set in over the central and southern Rocky Mountain regions and the western Great Plains, and moved slowly eastward, so that by the first few days of the third decade precipitation had overspread practically all districts east of the Rocky Mountains and continued in most localities until about the middle of the decade. During this period heavy rain fell in portions of the Gulf States and the Ohio Valley, and heavy snow in the central Plains region, particularly in Kansas and the Texas Panhandle. Generally fair weather overspread most sections thereafter, and continued until the last two days of the month, when there was precipitation over practically the entire country, with clearing weather moving in from the Northwest at the close of the month.

For the month as a whole the precipitation exceeded the normal in nearly all districts east of the 105th meridian, except in portions of New York, New England, and the lower Lakes, where less than the seasonal average was received. The amounts were heavy in southern Louisiana, portions of Alabama and Georgia, and also locally in the southern Appalachian Mountain districts, and in the southern Rocky Mountain regions.

In the northern Rocky Mountains and to the westward the amounts were generally less than the seasonal average, particularly in Idaho and the eastern portions of Oregon. In California the precipitation was nearly everywhere deficient, and particularly so in the higher mountain regions, where at points the total for the month was scarcely one-third the normal.

SNOWFALL.

The snowfall in most districts was light for the season, except in portions of the Great Plains, where it was unusually heavy, and in the western upper Lake region and portions of New York and New England, where rather heavy falls were received.

From 6 to 20 inches or more of snow fell in Kansas, Oklahoma, and portions of the Texas Panhandle during the latter part of the month, the amounts in places being heavier than in any previous December for which authentic records are available. In the far western mountains, particularly in California, the snowfall was unusually light for December.

At the close of the month there was practically no accumulation of snow in the Sierra Nevada and Cascade Ranges save at the highest elevations, and there was much less snow on the ground than usual at this season in the upper Lake region and also in the Northeastern States; but over the elevated portions of the central and southern Rocky Mountain districts the amounts were generally well above the normal.

RELATIVE HUMIDITY.

The relative humidity as a rule was below the normal in the northern Rocky Mountain and Plateau regions and over much of the Pacific Coast States. Elsewhere it

was higher than normal, particularly in the central and southern Rocky Mountain regions, where it was unusually high.

GENERAL SUMMARY.

The weather was favorable for farm work in the central and northern States, while rainy weather and wet soil interfered with outdoor work in the Gulf States, where less seeding was done than is usual during December. The gathering of corn was completed in most sections, but wet weather in the south delayed the completion of cotton picking, and at the end of the month some top crop still remained in the fields (from 10 to 25 per cent in the delta counties in Mississippi, and 5 to 10 per cent in South Carolina). The general absence of frost in the ground permitted plowing throughout nearly the entire month and much of this work was accomplished.

The temperature and rainfall both averaged above the normal in the principal winter grain-growing areas, and the grain entered the winter in unusually satisfactory condition in practically all sections of the country. Low temperature caused some damage to early potatoes and tender garden truck in Florida, but winter truck was generally in satisfactory condition because of the mild weather that prevailed most of the month.

The warm weather and ample precipitation were favorable for pastures in the central and eastern part of the country, and the general absence of any material snow cover over the northern Plains and mountain regions permitted grazing throughout nearly the entire month. Heavy snows were unfavorable for grazing in the central and southern Great Plains area, and stock suffered considerably from the cold of the latter part of the month. However the condition of stock continued generally good in practically all parts of the country. The weather was favorable for ripening citrus fruits except that confiderable damage was done to oranges in southern Calisornia by the low temperatures.

Average accumulated departures for December, 1918.

Districts.	Temperature.			Precipitation.			Cloudiness.		Relative humidity.	
	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure for the current month.	Accumulated departure since Jan. 1.	General mean for the current month.	Departure from the normal.	General mean for the current month.	Departure from the normal.
	° F.	° F.	° F.	Ins.	Ins.	Ins.	0–10.		P. ct.	
New England	31.4	+2.3	− 4.1	3.30	−0.10	− 5.40	6.9	+0.7	79	+ 3
Middle Atlantic	40.1	+4.9	+ 5.8	3.55	+0.40	− 6.50	6.5	+0.7	76	+ 1
South Atlantic	51.1	+3.9	+ 9.4	3.94	+0.50	−13.00	6.9	+2.0	81	+ 4
Florida Peninsula	67.4	+0.9	+ 7.0	2.80	+0.80	−16.10	5.9	+1.3	78	− 4
East Gulf	52.7	+3.5	+12.3	5.86	+1.40	+ 3.70	6.5	+1.0	80	+ 3
West Gulf	52.0	+2.9	+ 9.5	4.09	+1.20	− 5.50	5.3	+0.1	76	+ 2
Ohio Valley and Tennessee	43.9	+7.2	+ 6.2	4.69	+1.30	− 3.50	7.1	+0.7	78	+ 1
Lower Lakes	35.0	+5.9	+ 1.4	2.55	−0.30	− 2.90	7.9	+0.1	80	+ 1
Upper Lakes	30.9	+6.4	+ 3.0	2.83	+0.70	− 1.90	8.0	+0.7	85	+ 3
North Dakota	19.2	+7.4	+23.8	1.00	+0.40	− 2.90	7.0	+1.4	85	+ 4
Upper Mississippi Valley	35.8	+8.5	+13.5	2.24	+0.40	− 1.60	7.3	+1.3	84	+ 5
Missouri Valley	33.8	+7.0	+25.9	1.75	+0.70	− 1.90	6.3	+1.0	80	+ 4
Northern slope	26.7	+3.0	+11.9	0.62	−0.20	+ 0.90	5.8	+0.5	72	− 1
Middle slope	34.7	+1.7	+12.6	2.83	+1.70	+ 2.80	5.2	+1.0	74	+ 6
Southern slope	40.5	−3.2	+ 7.9	1.74	+0.90	− 4.80	4.3	−0.2	74	+ 6
Southern Plateau	39.2	−2.9	− 3.7	0.90	+0.40	+ 0.40	3.2	0.0	61	+10
Middle Plateau	28.3	−3.0	− 0.5	0.86	−0.20	− 0.90	4.6	−0.5	73	+ 1
Northern Plateau	31.5	−0.5	+17.1	0.62	−1.10	− 3.00	7.5	+0.6	76	− 4
North Pacific	42.0	−0.1	+14.0	6.44	−1.30	− 7.00	7.6	−0.2	88	+ 1
Middle Pacific	46.2	−2.3	+ 2.4	2.41	−2.00	− 5.30	4.0	−1.5	74	− 5
South Pacific	52.0	−1.0	+22.0	1.65	−0.50	+ 3.00	3.0	−1.3	65	− 3

WEATHER CONDITIONS OVER THE NORTH ATLANTIC DURING DECEMBER, 1917.

The data presented are for December, 1917, and comparison and study of the same should be in connection with those appearing in the REVIEW for that month. Chart IX (XLVI–109) shows for December, 1917, the averages of pressure, air temperature, water-surface temperature, and the prevailing direction of the wind at 7 a. m., 75th Meridian Time (Greenwich mean noon). Notes on the locations and courses of the more severe storms of the month are included in the following general summary.

PRESSURE.

The distribution of the mean atmospheric pressure for the month presented some unusual features. The Azores HIGH was slightly above the normal in intensity and considerably north of its usual position, and the mean pressure over the northeastern division of the ocean also was comparatively high. Over the remaining portions of the ocean pressure was near the normal.

The following table gives for a number of selected 5-degree squares the average pressure for each of the three decades of the month, as well as the highest and lowest individual readings reported during the month within the respective squares.

Pressure over the North Atlantic Ocean during December, 1917, by 5-degree squares.

Position of 5-degree square.		Decade means.			Extremes.			
					Highest.		Lowest.	
Latitude.	Longitude.	I.	II.	III.*	Pressure.	Date.	Pressure.	Date.
°	°	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*December.*	*Inches.*	*December.*
60–65 N.	20–25 W.	29.83	30.19	30.36	30.58	28	29.60	4
60–65 N.	0– 5 E.	29.66	29.85	30.15	30.49	30	29.09	1
55–60 N.	35–40 W.	29.77	30.24	30.26	30.55	25	29.32	4
55–60 N.	10–15 W.	29.92	30.18	30.46	30.62	28	29.59	1
50–55 N.	55–60 W.	29.87	30.32	30.05	30.86	17	29.50	4
50–55 N.	25–30 W.	29.89	30.30	30.46	30.59	28	29.63	4
50–55 N.	0– 5 W.	30.09	30.22	30.28	30.50	3	29.72	1
45–50 N.	65–70 W.	29.84	30.40	30.30	30.70	27	29.10	9
45–50 N.	40–45 W.	29.88	30.37	30.19	30.61	18	29.60	3
45–50 N.	10–15 W.	30.23	30.35	30.30	30.60	12,24	30.01	1
40–45 N.	50–55 W.	29.85	30.35	29.99	30.50	19	29.53	3
40–45 N.	25–30 W.	30.20	30.41	30.31	30.52	13	29.89	2
35–40 N.	75–80 W.	29.99	30.40	30.35	30.64	16	29.80	9
35–40 N.	35–40 W.	30.21	30.32	30.15	30.49	19	29.79	2
35–40 N.	10–15 W.	30.34	30.08	30.10	30.42	5,7	29.76	31
30–35 N.	50–55 W.	30.06	30.17	29.93	30.32	9	29.70	27
30–35 N.	25–30 W.	30.30	30.17	30.14	30.44	8	29.90	11,31
25–30 N.	90–95 W.	30.11	30.18	30.21	30.49	30	29.92	7
25–30 N.	60–65 W.	30.03	30.04	30.00	30.27	12	29.79	21
25–30 N.	15–20 W.	30.25	30.06	30.04	30.35	7	29.79	31
20–25 N.	75–80 W.	30.03	30.01	30.07	30.20	10,15	29.90	8,19
20–25 N.	50–55 W.	30.05	29.95	29.96	30.15	10	29.70	27
15–20 N.	35–40 W.	29.93	29.90	29.94	29.99	10	29.86	30
10–15 N.	80–85 W.	30.05	29.95	29.98	30.20	8	29.85	12,27

* Mean of last 11 days of the month.

The values presented in the above table are based on the interpolated daily pressure for each square on the daily synoptic charts of the North Atlantic, compiled by the marine section of the Weather Bureau. The extremes are the highest and lowest actual readings observed within the respective squares.

GALES.

According to the records of vessels in the steamer lanes, gales were comparatively rare in these waters during the month, although, due to war conditions, few reports were received from the eastern and central sections. The number of days on which gales occurred in the waters adjacent to the American coast was also

below the normal, with the exception of the 5-degree square between latitude 35° to 40°, longitude 70° to 75°, where they were reported on eight days.

On December 1 there was a LOW (I on Chart IX) central near New York, where the barometer reading was 29.68 inches; light to moderate winds prevailed along the American coast, although one vessel near St. Johns, Newfoundland, reported a northeasterly gale of about 50 miles an hour. This disturbance moved rapidly eastward, and on the 2d surrounded Nova Scotia; it had increased somewhat in intensity, and moderate northwesterly gales were encountered over a limited area off the North Carolina and Virginia coasts. Low I continued in its easterly movement, and on the 3d the center was near Sydney, Cape Breton Island; it had remained about the same in intensity, and there was little change in the condition of wind and weather since the previous day. On the 4th it was central near St. Johns, Newfoundland, and light winds with fog prevailed in the southerly quadrants.

On the 5th there was a LOW of slight intensity (II on Chart IX) near Brownsville, Tex.; it moved rapidly eastward, and on the 6th was off the coast of southern Georgia, where light southerly winds were the rule. This disturbance, increasing rapidly in intensity, was central near latitude 39°, longitude 64°, on the 7th, and northeasterly gales of over 50 miles an hour were reported from its westerly quadrants. Low II then curved sharply toward the north, and on the 8th the center was near the west coast of Newfoundland. A few reports denoting moderate gales were received from vessels off the American coast between the 37th and 42d parallels.

From the 1st to the 8th a LOW of considerable intensity remained practically stationary near the coast of northern Europe, although it is impossible to determine the weather conditions accurately on account of lack of reports.

On the 8th there was a disturbance central near Savannah, Ga., and moderate southeasterly gales prevailed along the coast between Hatteras and the Virginia Capes. This LOW moved rapidly northward, increasing in intensity, and on the 9th the center was near Quebec, where the barometric reading was 29.08 inches. The storm area had increased in extent since the previous day, and gales of from 40 to 50 miles an hour prevailed over the southerly quadrants. This depression drifted slowly northward, and on the 10th was in the vicinity of Father Point, while gales swept the same region as on the previous day. The LOW then moved rapidly toward the east, decreasing in intensity, and on the 11th it covered the greater part of Newfoundland; one vessel near latitude 41°, longitude 62° encountered a westerly gale of 55 miles an hour, accompanied by hail and snow, while other reports received from that region denoted light to moderate winds.

On the 14th a well-developed LOW was central near Boston, where the barometer reading was 29.14 inches, and strong westerly gales occurred between the 70th meridian and the American coast and the 38th and 41st parallels.

On the 16th a well-developed depression covered the greater part of England, and moderate northerly gales were reported along the European coast as far south as Bordeaux. This LOW moved rapidly southward, and on the 17th was central near Bilbao, Spain, and heavy weather was still encountered between the 40th and 50th parallels. It moved but little during the next 24 hours, and had decreased in intensity, as on the 18th no winds of gale force were reported from European waters.

On the 19th a LOW of slight intensity covered a large area in the West Indies and the Caribbean Sea, the center being somewhere near Porto Rico. At the same time a well-developed HIGH with a crest of 30.64 inches was central near St. Johns, Newfoundland. Vessels in the vicinity of Hatteras encountered strong northeasterly gales, while along the American coast, to the north and south of that point, moderate winds were reported. From the 20th to the 22d this slight depression remained nearly stationary between the Bermudas and the Azores, and was attended by light to moderate winds, with fog in the northern quadrants. On the 24th there was a LOW central about 150 miles off the east coast of Labrador, and at the same time a HIGH, with a crest of 30.60 inches, had its center near latitude 50°, longitude 22°, and vessels between these areas experienced moderate southerly gales.

While there were a number of slight depressions over various portions of the ocean during the remainder of the month, no winds of gale force were recorded until the 31st, when vessels near the American coast between the 33d and 36th parallels encountered moderate northeasterly gales.

AIR TEMPERATURE.

The month of December, 1917, was one of the coldest on record in the eastern part of the United States, while the mean temperature of the air over the Atlantic Ocean was, for the most part, above the normal, as positive departures of from 1 to 6 degrees were the rule over the northern steamer lanes.

On the Gulf of Mexico the temperatures were very irregular, the departures varying from −2 to +5 degrees, while in the southeastern division of the ocean they ranged from 0 to +4 degrees.

The greatest monthly range in temperature occurred, as usual, in the 5-degree square that included the east coast of Labrador, where the thermometer reading was 44° F. on the 8th and 26° F. on the 12th. The following table gives the temperature departures for the month at a number of Canadian and United States Weather Bureau stations on the Atlantic and Gulf coasts:

	°F.		°F.
St. Johns, Newfoundland	+3.1	Norfolk, Va	−9.2
Sydney, Cape Breton Island	−0.5	Hatteras, N. C	−8.5
Halifax, Nova Scotia	−4.1	Charleston, S. C	−9.3
Eastport, Me	−7.5	Key West, Fla	−3.7
Portland, Me	−9.3	Tampa, Fla	−2.7
Boston, Mass	−7.9	Mobile, Ala	−3.3
Nantucket, Mass	−7.3	New Orleans, La	−3.0
Block Island, R. I	−9.2	Galveston, Tex	−3.5
New York, N. Y	−9.0	Corpus Christi, Tex	−0.8

WATER-SURFACE TEMPERATURE.

Off the Banks of Newfoundland the mean monthly temperature of the water, as compared with the normal, was as usual, very irregular, the departures ranging from −2 to +4 degrees over a comparatively limited area. The temperatures for the greater part of the northern steamer lanes were somewhat cooler than usual, the same conditions holding true in the Gulf of Mexico and in the waters adjacent to the American coast, while in the vicinity of the Maderias and the Azores the departures were slightly positive. The greatest range in tempera-

ture in the water occurred in the square between latitude 45° to 50°, longitude 40° to 45°, where the thermometer reading was 40° on the 19th and 59° on the 20th.

FOG.

The number of days on which fog was observed was considerably below the normal over all sections of the ocean. On the Banks of Newfoundland, where the greatest amount usually occurs, it was reported on only two days, while in no other 5-degree square was it observed on more than one day.

HAIL AND SNOW.

Hail was observed on only one day, the 11th, in the square between latitude 40° to 45°, longitude 60° to 65°.

Snow was reported on two days in the region between latitude 35° to 40°, longitude 70° to 75°, and also between latitude 40° to 45°, longitude 60° to 65°, while it occurred on one day in a number of squares in the western division of the ocean.

Winds of 50 mis./hr. (22.4 m./sec.) or over, during December, 1918.

Station.	Date.	Velocity.	Direction.	Station.	Date.	Velocity.	Direction.
Birmingham, Ala.	21	52	se.	North Head, Wash.	12	62	s.
Block Island, R. I.	1	60	w.	Do.	13	60	s.
Buffalo, N. Y.	1	60	nw.	Do.	19	60	s.
Do.	2	56	sw.	Do.	28	78	se.
Do.	25	60	sw.	Do.	29	54	nw.
Cheyenne, Wyo.	2	58	w.	Pensacola, Fla.	20	55	se.
Do.	3	58	w.	Do.	24	62	sw.
Cleveland, Ohio.	6	52	nw.	Pittsburgh, Pa.	6	51	nw.
Columbus, Ohio.	5	50	nw.	Point Reyes Light,			
Ellendale, N. Dak.	22	50	nw.	Cal.	8	70	s.
Erie, Pa.	10	55	se.	Do.	20	85	nw.
Flagstaff, Ariz.	7	50	sw.	Do.	28	50	nw.
Green Bay, Wis.	24	50	ne.	Do.	29	74	nw.
Mount Tamalpais,				Providence, R. I.	1	54	nw.
Cal.	5	56	se.	Sandy Hook, N. J.	1	56	nw.
Do.	8	70	se.	Do.	6	57	nw.
Do.	20	50	nw.	Do.	14	50	s.
Nantucket, Mass.	17	56	ne.	Tatoosh Island,			
New York, N. Y.	1	65	w.	Wash.	1	58	s.
Do.	4	54	nw.	Do.	3	50	s.
Do.	5	57	nw.	Do.	8	60	sw.
Do.	6	75	nw.	Do.	10	68	s.
Do.	14	52	s.	Do.	12	50	sw.
North Head, Wash.	3	62	se.	Do.	13	58	s.
Do.	4	64	s.	Do.	19	50	e.
Do.	8	54	se.	Do.	28	68	w.
Do.	10	74	s.	Trenton, N. J.	6	60	nw.
Do.	11	52	s.				

CONDENSED CLIMATOLOGICAL SUMMARY.

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation by sections, December, 1918.

Section.	Temperature.							Precipitation.					
	Section average.	Departure from the normal.	Monthly extremes.					Section average.	Departure from the normal.	Greatest monthly.		Least monthly.	
			Station.	Highest.	Date.	Station.	Lowest. Date.			Station.	Amount.	Station.	Amount.
	°F.	°F.		°F.			°F.	In.	In.		In.		In.
Alabama	50.3	+4.4	Ashville	82	11	St. Bernard	16 27†	5.70	+1.16	Union Springs	11.13	Cochrane	2.30
Arizona	40.5	−1.9	Sentinel	83	4	2 stations	−22 26	1.82	+0.60	Final Ranch	4.14	Yuma	0.24
Arkansas	47.6	+5.9	Camden	88	10	4 stations	9 26	5.58	+1.60	Alicia	12.90	Helena	1.68
California	43.8	−2.9	2 stations	89	3†	Madeline	−16 31	2.10	−1.93	Crescent City	7.12	2 stations	0.00
Colorado	23.8	−1.2	2 stations	73	4†	Gunnison	−36 26	1.26	+0.30	Cumbres	3.78	Cathedral	0.04
Florida	60.9	+1.5	Homestead	90	25	Garniers (near)	23 29	3.60	+0.99	Apalachicola	15.88	Ritta	0.16
Georgia	51.6	+4.8	Glennville	82	14	Ramhurst	15 27	6.36	+2.18	Toccoa	11.62	Augusta	2.20
Hawaii (November)	72.4	+0.7	Mahukona	92	9	Waimea	50 16	9.90	+1.84	Glenwood	27.54	Puuhele, Mauri	1.96
Idaho	25.7	−0.3	3 stations	65	9†	French Gulch	−32 31	0.92	−1.20	Prichard	4.41	2 stations	0.05
Illinois	38.4	+8.2	Carbondale	74	9†	Morrison	− 1 26	3.50	+1.34	Palestine	9.53	Freeport	1.47
Indiana	39.9	+7.6	Seymour	74	17	Hammond	1 31	5.38	+2.67	Vincennes	9.17	Hammond	2.01
Iowa	32.7	+8.8	Columbus Junction	68	8	2 stations	− 7 25†	1.30	+0.08	Oskaloosa	3.30	Le Mars	0.37
Kansas	35.6	+4.4	2 stations	76	8	Salina	−15 25	2.74	+1.83	Scott City	6.03	Oketo	0.94
Kentucky	44.8	+7.7	2 stations	75	10	Junction City	14 27	4.44	+0.52	2 stations	7.10	Williamsburg	2.24
Louisiana	55.1	+3.3	Donaldsonville	88	13	Calhoun	15 26	5.93	+1.31	Houma	13.62	Monroe	2.34
Maryland-Delaware	40.2	+6.0	2 stations	71	14	Oakland, Md.	7 29	4.23	+0.60	Union Bridge, Md.	5.43	Western Port, Md.	2.51
Michigan	30.4	+4.7	Wasepi	62	22	Humboldt	−16 26	2.84	+0.73	Allegan	5.57	Humboldt	0.86
Minnesota	22.8	+7.3	Wheaton	60	7	Hallock	−28 31	1.41	+0.58	New Ulm	3.71	Ada	0.49
Mississippi	52.0	+4.9	Greenwood	83	13	Anguilla	16 26	4.12	−1.21	McNeill	9.37	Grenada	1.60
Missouri	40.0	+6.6	Marble Hill	83	6	Warsaw	−12 26	3.21	+1.14	Poplar Bluff	8.65	St. Charles	1.21
Montana	27.3	+4.1	Boulder	80	1	3 stations	−36 31	0.53	−0.31	Trout Creek	5.40	5 stations	T.
Nebraska	30.3	+4.4	3 stations	73	4†	Kirkwood	−22 31	1.40	+0.66	Brewster	3.61	Wahoo	0.37
Nevada	27.8	−3.3	Beatty	74	3	Potts	−21 24	0.69	−0.22	Sharp	2.25	Oasis Ranch	0.05
New England	28.1	+2.1	Fall River, Mass.	64	14	Van Buren, Me.	−21 8	3.25	−0.10	Springfield, Mass.	5.09	Houlton, Me.	1.05
New Jersey	37.5	+4.6	Tuckerton	66	23	Culvers Lake	6 7	3.92	+0.07	Long Branch	4.94	Paterson	3.21
New Mexico	29.2	−3.9	Deming	73	4†	Elizabethtown	−28 25	1.62	−0.75	Mogollon Ranger Sta	4.17	Loving	0.19
New York	31.2	+4.5	Wappingers Falls	62	23	North Lake	−13 7	2.77	−0.28	Adams Center	6.51	Cape Vincent	0.48
North Carolina	46.1	+4.7	Newbern	80	9†	2 stations	9 27	5.58	+1.46	Rock House	14.34	Hot Springs	1.07
North Dakota	18.3	+5.3	2 stations	65	1†	Minot	−41 31	0.89	+0.35	Grand Forks	2.29	Lisbon	0.05
Ohio	39.3	+8.4	Peebles	72	10	London	12 30	3.53	+0.61	Montpelier	6.24	Wickliffe	1.53
Oklahoma	42.1	+2.3	Pauls Valley	82	9	Newkirk	−10 25	3.76	+1.99	Antlers	6.25	Meeker	2.05
Oregon	34.3	−3.2	Warmspring	70	3	Lavine	−21 31	3.25	−2.56	Astoria	11.22	Sunrise Valley	0.03
Pennsylvania	36.6	+5.5	Grove City	72	8	Ebensburg	− 1 28	3.38	+0.18	Bustleton	5.74	Lawrenceville	0.90
Porto Rico	74.5	0.0	Guanica Centrale	93	18	2 stations	54 25	3.66	−1.17	Dorado	8.32	Hac. Potala	0.69
South Carolina	50.8	+4.5	Oaks	82	14	Walhalla	17 29	5.35	+1.96	Walhalla	13.44	Paris Island	1.16
South Dakota	25.9	+5.2	Howell	70	6	Pine Ridge	−25 24	1.02	+0.61	Greenmont	2.80	Lemmon	0.10
Tennessee	46.8	+7.0	Dyersburg	79	13	Erasmus	7 27	4.29	−0.41	Copperhill	9.69	Elizabethton	1.95
Texas	49.8	+1.5	Mercedes	90	12	Dalhart	− 6 25†	3.59	+1.26	Clarksville	8.36	0.2 Ranch	0.30
Utah	25.7	−0.9	Springdale	73	4	East Portal	−29 24	0.85	−0.17	Lockerby	2.99	2 stations	0.00
Virginia	42.3	+5.0	Franklin	76	14	Mineral	10 30	4.03	+0.71	Mayhurst	6.90	Swansonville	2.42
Washington	34.5	+1.4	2 stations	67	4	Anatone	−10 31†	4.41	−0.20	Forks	24.47	Maryhill	0.10
West Virginia	41.0	+7.3	Charleston	74	15	Marlinton	0 30	4.41	+1.00	Terra Alta	8.14	Clay	2.61
Wisconsin	28.3	+8.0	Delavan	58	8	Solon Springs	−20 25	1.68	+0.36	Manitowoc	3.43	Prairie du Chien	0.78
Wyoming	23.6	+2.7	Crow Hill	69	14	Sheridan Creek R. S.	−34 31	0.45	−0.36	Willow Springs R. S.	1.23	4 stations	T.

† Other dates also.

TABLE I.—*Climatological data for Weather Bureau Stations, December, 1918.*

Districts and stations.	Elevation of Instruments.			Pressure.			Temperature of the air.											Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.														Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to mean of 24 hours.	Departure from normal.	Mean max.+mean min.÷2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01 inch or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.														
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°*F.*	°*F.*	°*F*		°*F*	°*F.*		°*F*	°*F.*	°*F.*	°*F.*			%	*In.*	*In.*		*Miles*															*0–10*	*In.*	*In.*
New England.							**31.4**	**+2.3**												**79**	**3.30**	**−0.1**																**6.9**		
Eastport	76	67	85	30.00	30.09	+0.11	26.8	+1.5	50	15	33	4	31	21	24	25	23	87	2.31	−1.7	16	9,327	nw.	41	e.	25	6	7	18	7.3	12.4	0.5
Greenville	1,070	6	....	28.89	30.11	.....	20.6	.....	47	21	27	− 6	31	15	34	.....	.....				3.49	.....	19	.....	.....	.....	.....	.....	8	6	17	.....	26.9	8.0
Portland, Me.	103	82	117	30.00	30.13	+ .10	28.0	+0.9	56	23	33	10	31	23	22	26	22	79	4.30	+0.6	20	6,201	nw.	38	nw.	1	9	3	19	6.8	14.4	4.6
Concord	288	70	79	29.79	30.12	+ .06	26.8	+0.4	53	21	34	4	11	19	32	.....	.....				3.52	+0.2	15	2,773	n.	28	nw.	1	9	4	18	6.7	13.1	1.5
Burlington	404	11	48	29.67	30.13	+ .08	25.4	+2.9	52	23	32	0	31	19	24	.....	.....				1.78	+0.1	16	8,517	s.	41	s.	22	4	4	23	8.0	20.5	8.0
Northfield	876	12	60	29.16	30.14	+ .09	23.5	+3.1	51	23	32	− 4	31	15	31	21	19	85	2.24	−0.5	10	4,533	s.	35	nw.	1	4	6	21	7.8	14.6	7.5
Boston	125	115	188	29.97	30.11	+ .06	34.7	+3.1	63	15	41	13	7	28	24	31	26	72	3.21	−0.2	15	6,992	nw.	39	nw.	1	8	5	18	6.8	8.4	0.1
Nantucket	12	14	90	30.08	30.09	+ .04	38.2	+1.5	57	23	44	19	7	33	27	35	32	81	3.65	0.0	16	12,457	nw.	56	ne.	17	6	3	22	7.6	0.6	0.0
Block Island	26	11	46	30.07	30.10	+ .04	38.3	+1.7	57	15	44	18	7	32	30	36	33	82	4.44	+0.6	14	14,557	nw.	60	w.	1	9	3	19	6.8	T.	0.0
Providence	160	215	251	29.93	30.11	+ .05	34.0	+2.4	60	15	41	12	7	27	22	31	26	75	3.14	−0.7	15	8,557	nw.	54	nw.	1	9	7	15	6.0	5.5	0.0
Hartford	159	122	140	29.95	30.13	+ .06	33.6	+3.8	59	15	40	14	7	27	25	30	25	75	3.56	0.0	15	4,003	n.	33	nw.	1	9	3	19	6.5	4.2	0.0
New Haven	106	117	155	30.00	30.13	+ .06	36.0	+4.2	59	23	43	17	7	29	22	32	27	73	4.21	+0.6	15	6,719	ne.	38	n.	1	10	8	13	5.5	1.0	0.0
Middle Atlantic States.							**40.1**	**+4.9**												**76**	**3.55**	**+0.4**																**6.5**		
Albany	97	102	115	30.02	30.14	+ .06	32.2	+4.7	53	15	39	7	7	26	26	29	25	77	2.16	−0.4	10	5,396	s.	28	ne.	9	6	7	18	7.2	4.9	0.0
Binghamton	871	10	69	29.14	30.10	+ .01	34.8	+7.1	57	14	42	14	7	28	28	.....	.....				1.36	−1.1	14	3,539	nw.	28	w.	1	5	7	19	7.3	4.4	0.0
New York	314	414	454	29.78	30.13	+ .04	39.0	+4.6	61	14	46	21	6	32	22	34	28	67	3.70	+0.2	11	13,234	nw.	75	nw.	6	7	10	14	6.5	0.4	0.0
Harrisburg	374	94	104	29.74	30.16	+ .04	38.6	+5.8	64	8	44	23	2	33	23	34	29	71	3.65	+1.0	8	4,919	w.	29	nw.	6	7	8	16	6.7	0.1	0.0
Philadelphia	117	123	190	30.01	30.14	+ .03	40.9	+5.2	64	14	47	26	30	35	19	38	35	81	4.23	+1.2	8	7,399	nw.	42	n.	6	10	8	13	6.0	T.	0.0
Reading	325	81	98	29.80	30.17	.....	38.6	.....	63	14	45	24	30	32	19	35	30	73	4.74	+1.4	9	4,810	nw.	33	nw.	6	6	9	16	6.8	T.	0.0
Scranton	805	111	119	29.25	30.14	+ .04	36.2	+6.4	58	14	43	18	6	30	22	31	32	88	2.88	+0.3	15	4,524	sw.	35	nw.	1	5	9	17	6.7	4.6	0.0
Atlantic City	52	37	48	30.08	30.14	+ .04	41.0	+4.6	62	9	47	23	30	35	22	38	34	80	4.02	+0.3	11	6,189	nw.	38	ne.	17	9	9	13	5.8	T.	0.0
Cape May	18	13	49	30.14	30.16	+ .05	41.2	+3.2	62	9	47	28	27	36	22	38	....				3.55	−0.2	14	.....	nw.	39	s.	6	7	11	13	6.2	0.2	0.0
Sandy Hook	22	10	57	30.11	30.13	.....	39.3	.....	60	14	44	24	7	34	19	36	31	75	3.38	.....	8	12,770	w.	57	nw.	6	10	10	11	5.6	T.	0.0
Trenton	190	159	183	29.91	30.12	.....	38.4	.....	64	14	45	22	30	32	20	34	30	76	3.86	+0.7	8	8,694	w.	60	nw.	6	9	8	14	6.2	T.	0.0
Baltimore	123	100	113	30.02	30.15	+ .02	41.9	+5.0	67	9	48	25	30	35	23	37	31	69	4.72	+1.6	9	4,464	sw.	24	s.	22	9	9	13	6.1	T.	0.0
Washington	112	62	85	30.02	30.15	+ .02	41.6	+5.5	67	9	48	24	27	35	25	36	31	72	4.65	+1.5	10	4,625	nw.	44	nw.	6	8	7	16	6.3	T.	0.0
Lynchburg	681	153	188	29.39	30.15	+ .01	42.9	+4.6	71	8	51	18	30	35	31	38	33	74	2.59	−0.7	12	5,309	w.	37	nw.	6	8	7	16	6.1	T.	0.0
Norfolk	91	170	205	30.05	30.15	+ .02	47.4	+4.4	74	14	54	26	29	41	25	43	40	79	2.94	−0.6	11	10,495	ne.	44	nw.	6	7	9	15	6.4	T.	0.0
Richmond	144	11	52	30.09	30.16	+ .02	43.2	+2.2	70	9	51	20	30	36	29	39	35	77	4.79	+1.8	12	5,957	sw.	42	nw.	6	6	5	20	7.1	T.	0.0
Wytheville	2,293	49	55	27.70	30.14	+ .01	40.6	+5.3	64	10	48	19	29	33	31	36	32	79	3.03	−0.7	12	5,395	w.	36	w.	5	8	2	24	6.5	0.1	0.0
South Atlantic States.							**51.1**	**+3.9**												**81**	**3.94**	**+0.5**																**6.9**		
Asheville	2,255	70	84	27.75	30.16	.00	43.6	+5.8	68	10	51	18	27	36	30	39	34	75	4.73	+0.7	12	7,174	nw.	32	e.	11	8	6	17	6.7	2.1	0.0
Charlotte	773	153	161	29.28	30.14	− .02	47.2	+4.3	71	14	55	24	29	39	25	43	40	82	4.35	+0.5	13	4,650	ne.	27	nw.	4	6	9	16	6.5	0.3	0.0
Hatteras	11	12	50	30.10	30.11	− .02	51.6	+2.8	68	13	57	33	30	46	23	49	47	85	4.58	−0.5	11	12,675	ne.	44	n.	17	8	5	18	6.8	0.0	0.0
Manteo	12	4	46	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Raleigh	376	103	110	29.74	30.15	.00	46.6	+3.9	74	14	54	24	30	39	26	42	40	83	4.33	+1.2	12	6,544	ne.	32	nw.	4	7	3	21	7.5	T.	0.0
Wilmington	78	81	91	30.06	30.15	.00	52.0	+4.8	76	14	59	28	29	45	26	47	43	81	4.67	+1.6	11	5,863	w.	30	sw.	24	8	7	16	6.5	T.	0.0
Charleston	48	11	92	30.09	30.14	− .01	53.5	+2.2	74	14	60	29	29	47	25	49	46	81	3.17	0.0	11	8,082	w.	36	e.	1	9	1	21	6.8	0.0	0.0
Columbia, S. C.	351	41	57	29.77	30.16	.00	51.2	+4.0	76	14	59	28	29	43	29	45	42	78	3.91	+1.0	12	5,564	sw.	26	ne.	21	6	6	19	7.1	T.	0.0
Augusta	180	62	77	29.95	30.14	− .02	52.3	+5.3	75	14	60	28	29	44	27	48	45	83	3.07	−0.4	10	4,728	w.	27	s.	23	5	6	20	7.4	T.	0.0
Savannah	65	150	194	30.08	30.15	.00	54.4	+3.1	75	14	61	30	29	48	23	50	46	80	4.00	+0.9	11	9,172	w.	39	nw.	4	7	2	22	7.2	0.0	0.0
Jacksonville	43	200	245	30.09	30.14	.00	58.2	+3.0	77	14	65	34	29	52	22	53	51	82	2.60	−0.4	10	9,281	w.	36	sw.	14	8	5	18	6.9	0.0	0.0
Greenville, S. C.	1,013	113	122	29.01	30.12	.....	47.9	.....	80	10	55	23	29	41	23	42	37	75	7.37	.....	12	6,917	ne.	30	sw.	14	8	10	13	5.8	T.	0.0
Florida Peninsula.							**67.4**	**+0.9**												**78**	**2.80**	**+0.8**																**5.9**		
Key West	22	10	64	30.06	30.08	.00	71.7	+1.6	84	1	76	55	30	67	17	66	63	80	2.11	+0.3	7	8,566	ne.	33	w.	15	10	9	12	5.5	0.0	0.0
Miami	25	71	79	30.09	30.12	.....	67.8	−0.2	82	1	74	44	29	62	22	62	60	78	4.11	+1.9	9	6,897	e.	28	e.	20	9	13	9	5.6	0.0	0.0
Tampa	35	79	92	30.10	30.14	+ .02	62.6	+1.4	81	14	71	38	29	55	28	56	52	76	2.19	+0.2	9	4,849	ne.	24	e.	20	9	3	19	6.6	0.0	0.0
East Gulf States.							**52.7**	**+3.5**												**80**	**5.86**	**+1.4**																**6.5**		
Atlanta	1,174	190	216	28.89	30.15	− .01	48.2	+3.6	67	8	55	23	29	42	27	44	40	79	5.46	+0.9	10	9,321	nw.	36	nw.	4	8	6	17	6.4	T.	0.0
Macon	370	78	87	29.75	30.15	− .01	50.9	+4.1	72	24	59	27	29	43	34	46	42	78	4.77	+0.4	8	4,742	sw.	23	se.	22	8	4	19	6.8	0.0	0.0
Thomasville	273	49	58	29.84	30.14	− .01	54.8	+2.3	77	12	62	29	29	48	27	50	46	81	8.13	+4.4	10	3,453	ne.	17	sw.	24	7	8	16	6.6	0.0	0.0
Pensacola	56	149	185	30.08	30.14	− .01	55.4	+1.5	72	11	61	31	26	50	26	52	49	81	6.25	+2.1	9	10,241	n.	62	sw.	24	8	5	18	6.5	0.0	0.0
Anniston	741	9	57	29.34	30.15	− .01	48.9	+4.7	73	11	58	26	29	40	38	.....	.....		5.51	+1.6	12	5,451	se.	32	e.	20	7	12	12	6.2	T.	0.0
Birmingham	700	11	48	29.37	30.15	− .01	50.4	+3.1	72	8	58	25	29	43	30	45	41	75	4.14	−0.5	10	6,140	nw.	52	se.	21	8	9	14	6.3	T.	0.0
Mobile	57	125	161	30.07	30.13	− .02	55.0	+3.5	72	13	62	29	26	48	29	51	48	82	4.92	+0.4	10	7,501	nw.	48	e.	20	8	9	14	6.3	0.0	0.0
Montgomery	223	100	112	29.90	30.16	.00	52.2	+3.2	73	8	59	29	26	46	31	48	45	82	8.36	+3.9	9	5,123	sw.	22	nw.	24	6	12	13	6.5	0.0	0.0
Corinth	469	6	....	.....	.....	.....	49.2	.....	76	10	59	23	29	40	41	.....	.....		4.03	.....	9	.....	s.	.....	.....	.....	.....	.....	5	13	13	.....	T.	.....
Jackson	304	5	....	.....	.....	.....	52.9	.....	80	12	63	20	20	43	39	.....	.....		3.95	.....	10	.....	se.	.....	.....	.....	.....	.....	13	8	10	.....	.....	.....
Meridian	375	85	93	29.72	30.13	− .03	52.2	+5.3	76	12	61	26	29	44	32	48	44	81	3.50	−1.7	8	4,709	sw.	44	se.	20	5	14	12	6.3	0.0	0.0
Vicksburg	247	65	74	29.85	30.14	− .01	53.9	+4.5	78	10	62	26	26	46	25	48	44	77	4.94	−0.1	7	5,507	s.	26	nw.	28	7	6	18	6.7	0.0	0.0
New Orleans	51	76	84	30.07	30.13	.00	57.5	+3.1	80	9	64	34	26	51	25	53	51	86	8.46	+4.0	6	5,061	nw.	31	e.	19	8	6	17	6.5	0.0	0.0
West Gulf States.							**52.0**	**+2.9**												**76**	**4.09**	**+1.2**																**5.3**		
Shreveport	249	77	93	29.84	30.12	− .01	52.0	+3.1	77	10	61	23	26	42	27	46	42	74	3.09	−1.3	6	5,522	s.	34	nw.	13	13	5	13	5.0	0.0	0.0
Bentonville	1,303	11	44	28.65	30.04	− .09	43.2	+5.7	68	8	52	16	26	34	29	.....	.....		4.04	+1.3	11	4,658	sw.	21	s.	8	14	8	9	4.7	1.6	0.0
Fort Smith	457	79	94	29.57	30.07	− .06	46.1	+4.4	74	9	54	19	26	38	33	41	37	75	4.40	+1.5	8	6,512	e.	43	sw.	23	15	6	10	4.9	T.	0.0
Little Rock	357	139	147	29.70	30.08	− .06	49.6	+6.1	75	10	58	19	26	41	27	44	40	74	7.95	+3.7	9	6,725	s.	32	nw.	27	13	6	12	5.5	T.	0.0
Brownsville	57	4	26	.....	.....	.....	61.7	.....	82	10	71	36	2	52	36	.....	.....		3.55	.....	8	.....	n.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Corpus Christi	20	69	77	30.09	30.11	− .01	58.8	+2.2	76	10	65	34	25	52	26	54	51	80	2.45	+1.1	10	7,797	se.	36	se.	12	8	8	15	6.4	0.1	0.0
Dallas	512	109	117	29.52	30.08	.....	49.8	.....	77	9	59	19	25	40	32	.....	.....		3.78	.....	8	6,696	s.	32	w.	23	16	4	11	4.5	0.0	0.0
Fort Worth	670	106	114	29.36	30.09	− .03	49.8	+2.3	76	9	59	18	25	40	33	45	41	77	4.08	+2.9	8	7,697	sw.	33	sw.	8	16	4	11	4.2	0.0	0.0
Galveston	54	106	114	30.06	30.12	.00	56.8	+0.5	80	10	62	34	24	52	26	53	50	81	3.46	−0.3	6	8,464	se.	38	nw.	13	8	7	16	6.4	0.0	0.0
Houston	138	111	121	29.96	30.11	.....	56.4	+1.9	79	10	65	29	26	48	31	.....	.....		3.16	.....	8	6,424	nw.	37	se.	23	11	7	13	5.3	T.	0.0
Palestine	510	64	72	29.57	30.11	− .01	52.3	+2.9	76	9	62	24	24	43	31	46	42	75	3.63	0.0	7	5,753	sw.	24	nw.	23	11	6	14	5.4	0.0	0.0
Port Arthur	34	58	66	30.06	30.10	.....	55.4	.....	80	10	62	29	26	48	24	51	49	84	3.88	.....	6	6,910	s.	40	e.	19	11	7	13	5.3	0.0	0.0
San Antonio	701	119	132	29.36	30.10	− .01	54.7	+1.6	78	8	64	30	26	46	30	48	43	72	3.61	+2.0	6	6,017	nw.	37	nw.	23	13	4	14	5.2	0.0	0.0
Taylor	582	55	63	29.50	30.12	+ .01	52.0	+1.4	76	8	62	24	26	42	35	.....	.....		4.21	+1.6	10	6,189	nw.	34	nw.	23	11	5	15	5.7	0.0	0.0

TABLE I.—*Climatological data for Weather Bureau stations, December, 1918.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.									Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.						Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.				Total.	Departure from normal.	Days with .01 or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
Ohio Valley and Tennessee.	*Ft.*	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F. 43.9	°F. +7.2	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	K 78	*In.* 4.69	*In.* +1.3		*Miles*								0–10 7.1	*In.*	*In.*
Chattanooga	762	189	213	29.32	30.15	− .01	48.5	+5.9	73	11	56	23	27	41	33	43	38	72	5.33	+1.0	10	6,243	sw.	31	nw.	4	7	9	15	6.5	T.	0.0
Knoxville	996	102	111	29.04	30.12	− .04	47.5	+7.8	69	11	54	21	27	40	26	43	38	75	5.32	+1.2	8	5,164	ne.	34	sw.	24	2	13	16	7.3	T.	0.0
Memphis	399	76	97	29.69	30.12	− .03	50.2	+6.7	75	10	57	23	26	43	21	45	41	73	4.58	+0.2	11	7,186	sw.	38	sw.	24	10	6	15	6.2	0.1	0.0
Nashville	546	108	191	29.53	30.12	− .03	47.4	+6.3	69	10	55	23	29	40	38	43	38	72	4.56	+0.7	12	7,928	s.	34	w.	24	10	7	14	6.1	T	0.0
Lexington	989	193	230	29.03	30.13	− .01	42.8	+6.4	64	13	50	18	26	36	29	.....	.....	.....	4.83	+1.5	15	7,575	sw.	40	s.	31	5	8	18	7.0	0.6	0.0
Louisville	528	219	255	29.51	30.10	− .04	44.8	+6.7	67	10	52	22	26	38	31	41	37	77	4.48	+0.8	13	9,223	s.	39	s.	13	7	6	18	7.0	1.0	0.0
Evansville	431	139	175	29.61	30.09	− .04	44.7	+8.3	70	13	52	22	29	38	32	41	37	79	5.83	+2.0	14	9,318	sw.	43	sw.	24	6	9	16	6.8	0.8	0.0
Indianapolis	822	194	230	29.16	30.06	− .06	40.3	+7.7	65	10	47	19	26	34	27	38	35	84	6.19	+3.2	15	9,228	s.	40	s.	10	5	7	19	7.5	1.2	0.0
Terre Haute	575	96	129	29.42	30.05	.....	41.0	.....	66	10	48	17	26	34	29	38	35	82	7.05	.....	14	7,445	sw.	36	sw.	24	4	12	15	7.2	0.7	0.0
Cincinnati	628	11	51	29.39	30.09	− .04	41.8	+7.4	66	13	49	20	26	35	29	38	35	79	4.68	+1.8	16	6,636	s.	31	sw.	24	4	10	17	7.2	1.0	0.0
Columbus	824	173	222	29.19	30.09	− .03	40.4	+7.6	64	13	47	20	26	34	25	37	34	80	3.23	+0.5	16	9,414	se.	50	nw.	5	5	6	20	7.3	0.8	0.0
Dayton	899	181	216	29.07	30.05	.....	41.3	+8.2	63	13	48	20	26	35	26	38	35	82	2.92	+0.3	19	8,438	sw.	37	sw.	24	6	4	21	7.2	0.9	0.0
Pittsburgh	842	353	410	29.18	30.10	− .01	41.0	+6.3	62	13	47	22	29	35	27	36	32	74	3.50	+0.8	15	8,866	sw.	51	nw.	6	6	2	23	7.8	1.4	0.0
Elkins	1,940	41	50	28.02	30.13	− .01	40.2	+7.7	67	14	49	10	30	31	37	36	33	83	5.93	+2.5	17	4,643	w.	30	w.	6	4	6	21	7.9	7.6	0.0
Parkersburg	638	77	84	29.45	30.12	− .02	43.3	+8.1	67	13	51	23	30	36	30	38	35	79	4.23	+1.5	16	4,415	sw.	32	nw.	6	6	2	23	7.8	1.8	0.0
Lower Lake Region.							35.0	+5.9										80	2.55	−0.3									7.9		
Buffalo	767	247	280	29.22	30.07	+ .01	35.0	+4.9	57	14	41	19	1	29	23	32	30	82	2.41	−1.0	17	12,274	w.	60	sw.	25	3	4	24	8.5	5.8	T.
Canton	448	10	61	29.60	30.10	.....	24.0	+1.3	54	14	32	− 5	27	16	35	.....	.....	.....	2.79	−0.8	18	7,000	e.	33	n.	1	8	6	17	6.8	17.8	4.2
Oswego	335	76	91	29.72	30.10	+ .04	31.8	+2.6	55	22	38	12	7	26	24	30	27	83	2.35	−1.2	15	8,285	s.	40	nw.	1	3	3	25	8.1	11.4	3.0
Rochester	523	97	113	29.51	30.10	+ .04	34.2	+5.3	58	14	40	14	7	28	28	31	27	74	2.33	−0.6	14	6,123	sw.	36	nw.	1	4	4	23	8.2	11.9	0.0
Syracuse	597	97	113	29.44	30.10	+ .03	32.6	+4.3	57	14	40	12	29	26	23	.....	.....	.....	2.26	−0.4	16	8,006	s.	48	nw.	1	2	7	22	8.0	10.6	0.5
Erie	714	130	166	29.28	30.06	− .01	38.2	+6.5	62	13	44	23	28	33	24	34	30	74	2.41	−0.6	14	11,485	sw.	55	se.	10	3	5	23	8.1	6.1	0.0
Cleveland	762	190	201	29.23	30.07	− .02	38.7	+7.6	62	13	44	22	29	34	23	35	31	76	1.58	−1.0	14	11,153	s.	52	nw.	6	5	3	23	8.0	2.0	0.0
Sandusky	629	62	103	29.37	30.07	− .04	38.8	+7.7	63	13	44	20	28	34	25	.....	.....	.....	2.71	+0.4	16	9,773	sw.	45	nw.	6	3	6	22	8.1	0.8	0.0
Toledo	628	208	243	29.37	30.07	− .01	38.0	+7.5	58	13	43	21	26	33	24	35	32	82	3.04	+0.7	14	10,261	sw.	42	ne.	24	4	8	19	7.4	0.5	0.0
Fort Wayne	856	113	124	29.12	30.07	.....	36.8	+9.5	56	8	42	16	26	31	26	34	32	83	5.30	.....	14	7,092	sw.	37	w.	5	5	7	19	7.5	0.9	0.0
Detroit	730	218	245	29.26	30.07	.00	36.4	+6.9	56	13	42	18	26	31	20	34	32	86	3.59	+1.2	13	7,991	w.	46	nw.	6	3	7	21	7.6	2.4	0.0
Upper Lake Region.							30.9	+6.4										85	2.83	+0.7									8.0		
Alpena	609	13	92	29.38	30.06	+ .04	30.0	+5.2	51	22	34	4	26	26	22	28	26	88	3.20	+1.0	14	8,663	w.	42	se.	10	2	9	20	8.1	22.6	6.0
Escanaba	612	54	60	29.36	30.05	+ .02	28.9	+7.3	45	8	34	11	1	24	24	28	26	89	2.35	+0.6	13	7,606	nw.	44	ne.	24	2	9	20	7.9	9.5	1.0
Grand Haven	632	54	92	29.34	30.04	− .01	34.0	+3.9	51	19	39	6	28	29	25	32	29	83	3.67	+1.2	14	9,170	e.	38	nw.	5	2	9	20	8.0	9.0	2.2
Grand Rapids	707	70	87	29.26	30.06	+ .01	34.5	+5.7	51	21	39	13	28	30	21	32	29	84	4.02	+1.5	14	4,817	se.	27	nw.	5	4	5	22	7.9	7.6	2.0
Houghton	684	62	99	29.28	30.03	+ .01	26.8	+5.9	42	7	31	9	26	22	17	.....	.....	.....	2.35	−0.1	18	6,461	e.	34	e.	10	1	1	29	9.4	20.7	8.8
Lansing	878	11	62	29.08	30.05	.....	32.9	+6.1	54	22	39	2	28	27	23	30	28	88	3.61	+1.5	16	4,875	sw.	25	nw.	5	5	4	22	7.9	10.0	2.0
Ludington	637	60	66	29.32	30.04	.....	33.2	.....	50	21	38	17	28	28	20	31	28	84	3.25	.....	16	8,751	se.	41	sw.	7	2	8	21	8.0	7.1	2.1
Marquette	734	77	111	29.24	30.07	+ .05	28.8	+5.9	46	8	33	14	1	24	16	26	24	82	2.94	+0.4	18	7,450	w.	39	sw.	7	3	4	24	8.2	29.5	5.6
Port Huron	638	70	120	29.34	30.05	− .01	33.8	+6.5	55	22	39	11	26	28	21	32	30	87	2.34	+0.2	12	7,952	nw.	39	nw.	5	4	10	17	7.3	1.6	0.1
Saginaw	641	48	82	29.34	30.05	.....	32.0	.....	54	8	38	6	28	26	22	30	28	88	2.59	+0.7	14	6,802	sw.	31	ne.	24	2	9	20	7.8	7.1	3.9
Sault Sainte Marie	614	11	61	29.36	30.08	+ .08	25.3	+4.8	42	8	30	− 1	1	21	21	24	20	82	2.45	+0.1	16	6,438	e.	34	w.	8	3	11	17	7.7	12.1	3.2
Chicago	823	140	310	29.13	30.04	− .04	37.7	+8.4	56	19	42	14	26	34	15	34	30	74	3.24	+1.2	15	9,341	w.	46	ne.	24	3	7	21	7.5	8.6	2.5
Green Bay	617	109	144	29.35	30.03	− .01	30.7	+9.4	51	19	36	13	27	26	17	28	25	81	1.81	0.0	12	8,331	sw.	50	ne.	24	2	4	25	8.6	7.4	1.6
Milwaukee	681	119	133	29.27	30.03	− .03	34.1	+8.1	55	8	39	15	26	29	18	32	31	90	3.03	+1.1	13	8,265	w.	40	ne.	24	1	11	19	7.8	9.8	3.0
Duluth	1,133	11	47	28.77	30.04	− .01	23.6	+5.9	44	8	29	1	23	18	28	22	21	93	2.03	+0.8	17	10,507	ne.	47	ne.	9	4	4	23	7.7	18.7	8.3
North Dakota.							19.2	+7.4										85	1.00	+0.4									7.0		
Moorhead	940	8	57	29.04	30.10	+ .02	18.0	+7.3	53	7	26	−20	31	10	32	16	14	88	1.30	+0.6	10	5,753	n.	29	n.	22	9	5	17	7.1	13.0	9.8
Bismarck	1,674	8	57	28.26	30.12	+ .04	21.6	+6.6	57	6	31	−29	31	12	34	19	17	86	1.02	+0.4	8	6,860	nw.	41	nw.	1	4	9	18	7.2	16.0	12.0
Devils Lake	1,482	11	44	28.42	30.07	+ .01	14.9	+6.9	44	7	23	−27	31	7	30	13	12	91	0.67	+0.3	9	7,064	sw.	39	ne.	30	7	5	19	6.8	11.4	8.5
Ellendale	1,457	10	56	28.45	30.08	.....	19.0	.....	58	7	28	−25	31	10	38	17	15	87	0.67	.....	7	10,264	nw.	50	nw.	22	3	7	21	7.8	6.7	4.6
Grand Forks	835	12	89	.....	.....	.....	13.2	.....	44	7	22	−30	31	4	37	14	.....	.....	2.29	.....	8	.....	w.	33	w.	5	7	3	21	.....	27.6	18.8
Williston	1,872	41	48	28.00	30.06	.00	22.4	+8.8	54	6	31	−30	31	14	32	19	15	75	1.00	+0.3	6	5,607	sw.	30	ne.	30	7	5	19	7.0	6.6	5.0
Upper Mississippi Valley.							35.8	+8.5										84	2.24	+0.4									7.3		
Minneapolis	918	10	208	29.00	30.01	.....	28.6	.....	49	7	34	8	25	23	20	.....	.....	.....	1.71	+0.8	14	8,321	nw.	41	nw.	3	3	4	24	8.5	4.8	3.4
St. Paul	837	201	236	29.08	30.02	− .06	28.7	+9.4	50	8	34	6	25	23	20	.....	.....	.....	2.05	+1.0	16	8,503	nw.	45	nw.	5	2	6	23	8.3	6.7	4.0
La Crosse	714	11	48	29.22	30.02	− .06	31.0	+8.2	52	21	36	11	27	25	24	.....	.....	.....	1.10	−0.2	14	3,574	s.	26	nw.	5	4	1	26	8.5	4.4	0.8
Madison	974	70	78	28.96	30.05	− .03	31.4	+8.7	53	19	36	7	26	26	19	30	28	92	2.19	+0.4	11	7,329	se.	45	n.	24	1	6	24	8.7	11.8	5.2
Wausau	1,247	4	.....	28.64	30.03	.....	26.5	.....	47	8	32	8	1	22	26	.....	.....	.....	1.03	.....	13	.....	se.	.....	.....	.....	3	2	26	8.7	5.8	1.4
Charles City	1,015	10	49	28.9	30.03	− .07	30.0	+11.0	52	21	36	8	25	24	23	28	26	89	1.19	−0.1	9	4,903	se.	24	w.	11	4	6	21	7.5	4.9	3.5
Davenport	606	71	79	29.3	30.04	− .06	35.5	+8.3	64	9	42	8	26	29	23	32	30	86	1.85	+0.2	11	5,404	e.	27	w.	3	4	10	17	7.1	8.8	5.2
Des Moines	861	84	97	29.0	30.02	− .09	34.2	+8.5	58	8	42	5	25	27	26	32	29	81	1.35	0.0	10	5,445	nw.	28	sw.	9	6	9	16	6.7	6.9	4.5
Dubuque	698	81	96	29.2	30.06	− .04	33.0	+8.5	55	8	39	5	26	27	23	30	28	85	1.90	+0.2	13	4,367	s.	30	nw.	3	3	9	19	7.8	10.7	5.6
Keokuk	614	64	78	29.3	30.06	− .06	37.8	+8.4	66	9	45	6	26	30	29	34	30	79	2.10	+0.2	10	5,639	sw.	30	n.	24	7	14	10	5.8	14.0	4.5
Cairo	356	87	93	29.6	30.06	− .09	45.8	+7.3	71	10	53	18	26	38	32	42	34	78	6.1	+2.8	12	7,231	s.	31	sw.	24	9	6	16	6.3	T.	0.0
Peoria	600	11	45	29.3	30.05	− .06	36.6	+8.5	67	9	44	6	26	29	27	33	3	87	2.80	+0.4	12	5,302	s.	28	ne.	24	6	13	12	6.2	7.0	2.9
Springfield, Ill.	644	10	91	29.34	30.03	− .09	39.2	+7.9	69	9	46	12	26	32	34	36	3	84	2.45	0.0	12	6,294	se.	28	nw.	3	6	7	18	6.9	2.6	0.0
Hannibal	534	74	109	29.4	30.04	− .08	39.1	+7.8	67	9	47	1	26	31	31	.....	.....	.....	1.79	+0.1	9	6,422	sw.	28	ne.	23	7	10	14	6.5	8.5	1.4
St. Louis	567	265	303	29.43	30.05	− .08	43.0	+7.5	74	9	50	14	26	36	37	38	34	75	2.69	+0.5	11	10,086	s.	40	nw.	24	9	10	12	5.5	0.5	0.0
Missouri Valley.							33.8	+7.0										80	1.75	+0.7									6.3		
Columbia, Mo.	781	11	84	29.20	30.05	− .07	39.8	+6.9	67	5	48	2	26	32	30	.....	.....	.....	2.30	+0.3	8	6,220	se.	27	nw.	3	9	12	10	5.3	8.1	T.
Kansas City	963	161	181	28.98	30.04	− .08	39.4	+7.9	67	8	46	6	25	32	25	35	30	73	2.98	+1.6	9	8,739	s.	34	nw.	24	12	5	14	5.8	16.4	7.5
St. Joseph	967	11	49	28.97	30.03	.....	37.2	.....	63	8	45	3	25	30	25	33	29	78	1.97	.....	7	6,293	nw.	29	nw.	24	10	10	11	5.4	8.7	5.0
Springfield, Mo.	1,324	98	104	28.63	30.06	− .07	41.3	+5.8	68	8	49	9	26	34	29	37	33	80	2.97	+0.3	10	8,421	se.	31	w.	2	16	3	12	4.9	4.9	0.0
Iola	984	11	50	28.97	30.04	− .08	38.8	+6.3	70	8	48	0	23	30	35	.....	.....	.....	3.22	+2.3	6	5,396	s.	22	ne.	23	10	9	12	5.6	9.6	3.0
Topeka	983	85	101	.....	.....	.....	37.6	+6.5	68	8	45	0	25	30	28	.....	.....	.....	2.37	+1.5	7	7,524	s.	33	n.	23	7	12	12	6.0	11.0	8.0
Drexel	1,299	10	53	28.60	30.01	.....	32.8	.....	61	7	40	− 3	31	25	29	30	28	87	0.95	.....	10	8,450	nw.	39	sw.	9	5	9	17	7.1	3.0	1.8
Lincoln	1,189	11	54	28.73	30.03	− .09	34.4	+7.5	62	5	42	− 4	31	27	29	31	28	78	0.83	+0.2	7	6,770	n.	32	nw.	3	5	8	18	7.1	2.9	1.6
Omaha	1,105	115	122	28.82	30.03	− .08	34.8	+7.7	61	7	42	0	31	28	27	32	28	78	0.72	−0.2	8	6,423	nw.	31	nw.	1	5	11	15	6.8	3.2	0.7
Valentine	2,598	47	54	27.28	30.09	− .01	27.4	+2.9	65	7	37	−10	31	18	35	24	21	80	0.80	+0.2	7	7,702	w.	39	nw.	30	8	7	16	6.5	4.0	1.5
Sioux City	1,135	94	164	28.77	30.02	− .10	32.2	+9.6	60	7	40	− 4	31	25	29	29	25	79	1.34	+0.6	10	9,143	nw.	49	nw.	31	4	9	18	6.9	1.2	0.4
Huron	1,306	59	74	28.64	30.09	− .01	25.1	+9.4	60	7	34	−14	31	16	35	22	19	84	0.91	+0.3	10	7,941	nw.	38	nw.	22	4	16	11	6.3	4.6	2.0
Pierre	1,572	70	75	28.36	30.09	− .01	25.5	+5.4	65	7	34	−12	31	16	37	22	18	76	1.45	+1.0	8	5,619	nw.	42	nw.	1	5	8	18	7.1	14.5	2.1
Yankton	1,233	49	57	28.68	30.03	− .08	29.7	+7.5	61	7	37	− 6	31	22	34	.....	.....	.....	1.08	+0.4	10	6,365	nw.	30	nw.	30	4	10	17	7.4	1.8	0.8

TABLE I.—*Climatological data for Weather Bureau stations, December, 1918.*

Districts and stations.	Elevation of instruments.			Pressure.			Temperature of the air.										Mean wet thermometer.	Mean temperature of the dew-point.	Mean relative humidity.	Precipitation.			Wind.					Clear days.	Partly cloudy days.	Cloudy days.	Average cloudiness, tenths.	Total snowfall.	Snow on ground at end of month.
	Barometer above sea level.	Thermometer above ground.	Anemometer above ground.	Station, reduced to mean of 24 hours.	Sea level, reduced to 24 hours.	Departure from normal.	Mean max. + mean min. ÷ 2.	Departure from normal.	Maximum.	Date.	Mean maximum.	Minimum.	Date.	Mean minimum.	Greatest daily range.					Total.	Departure from normal.	Days with .01, or more.	Total movement.	Prevailing direction.	Maximum velocity. Miles per hour.	Maximum velocity. Direction.	Maximum velocity. Date.						
	Ft.	*Ft.*	*Ft.*	*In.*	*In.*	*In.*	°F.	°F.	°F		°F	°F		°F	°F	°F	°F	°F	*K*	*In.*	*In.*		*Miles*							*0–10*	*In.*	*In.*
Northern Slope.							**26.7**	**+ 3.0**											**72**	**0.62**	**−0.2**									**5.8**		
Billings	3,140	5					31.4		61	7	42	−12	31	20	32					0.04		2		sw.				12	14	5		0.4	0.2
Havre	2,505	11	41	27.34	30.06	+ .01	26.4	+ 5.2	56	28	37	−15	31	16	40	23	19	79		0.09	−0.5	3	5,598	sw.	36	w.	2	6	11	14	6.2	2.4	0.9
Helena	4,110	87	114	25.81	30.13	.00	28.5	+ 3.7	64	4	36	−12	31	20	31	24	15	59		0.07	−0.7	2	5,313	sw.	46	sw.	2	8	8	15	6.3	0.6	0.5
Kalispell	2,962	11	34	26.99	30.14	+ .07	28.1	+ 4.2	58	4	34	− 6	31	22	24	26	22	77		0.87	−1.0	9	3,382	nw.	32	w.	4	5	5	21	7.8	1.5	0.4
Miles City	2,371	26	48	27.49	30.12	+ .02	31.0	+10.0	56	7	40	−16	31	22	35	26	24	85		0.65	0.0	6	4,290	se.	33	nw.	10	11	10	10	4.8	3.9	3.6
Rapid City	3,259	50	58	26.60	30.13	+ .04	29.8	+ 3.8	67	7	41	− 9	31	19	42	24	17	60		0.46	0.0	4	6,527	w.	49	nw.	10	11	6	14	5.5	3.8	T.
Cheyenne	6,088	84	101	23.94	30.10	+ .01	26.7	− 2.3	56	6	34	−12	31	19	27	22	16	68		0.58	+0.3	6	12,227	w.	58	w.	2	12	8	11	5.3	7.9	0.2
Lander	5,372	60	68	24.65	30.22	+ .07	30.9	+ 1.7	59	4	33	−23	31	8	41	16	10	71		1.13	+0.4	5	2,196	sw.	30	nw.	4	8	12	11	6.0	13.2	8.0
Sheridan	3,790	10	47	26.10	30.12		28.0		63	4	40	−18	31	16	38	23	17	68		0.21		5	3,871	nw.	39	nw.	1	13	7	11	4.6	1.6	0.8
Yellowstone Park	6,200	11	48	23.88	30.23	+ .07	20.4	− 1.2	46	6	29	−20	31	12	26	17	12	70		0.39	−1.4	10	6,556	s.	36	sw.	4	12	6	13	5.4	3.7	0.8
North Platte	2,821	11	51	27.10	30.13	+ .03	28.5	+ 1.9	69	4	39	− 6	31	18	41	23	20	78		1.31	+0.8	10	5,552	n.	27	n.	21	9	9	13	5.6	5.9	2.9
Middle Slope.							**34.7**	**+ 1.7**											**74**	**2.83**	**+1.7**									**5.2**		
Denver	5,292	106	113	24.70	30.10	+ .02	30.6	− 1.6	66	5	40	−10	31	21	29	25	18	63		1.40	+0.8	8	5,248	s.	28	nw.	1	11	11	9	5.3	19.6	8.1
Pueblo	4,685	80	86	25.28	30.11	+ .03	30.2	− 1.5	67	6	42	−11	31	18	43	25	18	67		0.92	+0.5	9	4,681	nw.	41	nw.	8	11	4	16	5.7	9.4	4.3
Concordia	1,392	50	58	28.55	30.06	− .05	35.0	+ 5.5	67	8	44	− 1	31	27	31	31	28	81		1.87	+1.4	8	6,436	nw.	30	sw.	8	6	11	14	6.6	6.4	4.1
Dodge City	2,509	11	51	27.49	30.08	− .02	34.0	+ 2.4	74	5	44	− 6	25	24	41	27	2	73		4.03	+3.5	10	8,173	nw.	44	nw.	8	16	7	8	4.3	20.5	6.0
Wichita	1,358	139	158	28.57	30.04	− .07	37.4	+ 3.2	69	8	46	− 5	25	28	34	30	82			3.31	+2.5	9	9,641	n.	35	n.	24	14	6	11	4.9	16.3	8.5
Altus	1,410	5					41.9		77	7	53	11	27	31	43					4.36		7		nw.				20	1	10		12.0	0.0
Muskogee	652	4					44.4		73	8	53	13	25	36	30					3.61		9		se.				13	8	10		0.8	0.0
Oklahoma	1,214	10	47	28.76	30.08	− .03	40.8	+ 2.2	71	8	50	0	25	32	30	36	3	78		3.04	+1.3	9	9,781	s.	34	s.	7	12	10	9	4.6	6.6	1.2
Southern Slope.							**40.5**	**− 3.2**											**74**	**1.74**	**+0.9**									**4.3**		
Abilene	1,738	10	52	28.25	30.10	− .01	46.0	+ 1.0	76	8	56	19	25	36	35	39	34	72		2.52	+1.4	8	7,425	sw.	34	s.	29	14	5	12	4.6	1.1	0.0
Amarillo	3,676	10	49	26.28	30.12	+ .03	42.3	− 4.1	64	5	42	− 2	31	23	35	27	23	76		2.78	+2.0	9	8,213	nw.	36	sw.	8	18	5	8	3.7	30.5	8.2
Del Rio	944	64	71	29.09	30.10	.00	50.6	− 1.8	72	10	60	27	1	41	33					0.69	−0.2	6	6,070	nw.	37	nw.	13	11	8	12	5.3	0.0	0.0
Roswell	3,566	75	85	26.39	30.11	+ .04	33.2	− 8.0	65	8	44	0	27	22	34	28	23	73		0.96	+0.4	7	4,245	n.	33	w.	8	18	7	6	3.5	8.0	1.1
Southern Plateau.							**39.2**	**− 2.9**											**61**	**0.90**	**+0.4**									**3.2**		
El Paso	3,762	110	133	26.22	30.06	+ .03	41.2	− 3.6	67	7	51	19	27	31	31	35	29	61		0.78	+0.3	8	7,937	nw.	36	w.	12	13	12	6	4.5	2.9	0.0
Santa Fe	7,013	57	66	23.18	30.10	+ .04	27.0	− 3.3	55	5	36	0	25	18	28	22	18	76		1.24	+0.5	8	5,577	n.	36	se.	31	15	10	6	4.2	14.4	5.0
Flagstaff	6,908	8	57	23.28	30.02	− .01	25.2	− 3.2	58	4	37	−10	31	14	39	24				1.81		6		se.	50	sw.	7	18	8	5		16.7	8.0
Phoenix	1,108	76	81	28.84	30.02	− .02	49.6	− 2.3	79	4	62	30	25	37	41	43	35	64		1.16	+0.6	5	3,483	e.	25	sw.	7	21	3	7	3.1	0.0	0.0
Yuma	141	9	54	29.87	30.02	− .03	52.8	− 2.9	77	5	66	27	31	40	35	43	31	49		0.21	−0.2	3	4,040	n.	26	n.	18	24	4	3	1.7	0.0	0.0
Independence	3,910	11	42	26.03	30.13	+ .01	39.3	− 2.3	66	3	51	18	31	28	36	30	19	49		1.02	+0.2	3	5,181	nw.	27	nw.	22	22	7	2	2.6	0.1	0.0
Needles	488	4		29.52	30.04		50.2		73	3	61	28	3	39	36					1.20		4						19	3	9			
Middle Plateau.							**28.3**	**−3.9**											**73**	**0.86**	**−0.2**									**4.6**		
Reno	4,532	74	81	25.52	30.18	+ .03	32.1	−1.9	66	5	44	8	25	20	41	27	20	67		0.40	−1.3	5	3,855	w.	36	se.	8	16	9	6	3.8	4.0	T.
Tonopah	6,040	12	20																													
Winnemucca	4,344	18	56	25.79	30.21	+ .05	24.9	−5.8	52	6	37	− 9	31	13	35	22	19	82		0.60	−0.5	7	4,414	ne.	25	sw.	8	14	6	11	4.8	3.5	0.8
Modena	5,470	10	43	24.62	30.13	+ .01	23.6	−5.1	62	4	30	−12	31	15	42	22	16	71		2.01	+1.4	8	5,332	w.	34	sw.	8	15	11	5	3.7	3.8	0.6
Salt Lake City	4,350	163	203	25.68	30.15	.00	31.2	−0.9	55	6	37	9	31	25	21	27	21	65		0.52	−0.8	5	4,784	nw.	41	se.	21	9	10	12	5.8	5.7	T.
Grand Junction	4,602	82	95	25.45	30.14	+ .04	25.8	−1.4	42	8	35	2	31	18	27	25	20	78		0.85	+0.4	9	2,920	se.	25	se.	8	15	4	12	4.8	5.0	2.1
Northern Plateau.							**31.5**	**−0.5**											**76**	**0.62**	**−1.1**									**7.5**		
Baker	3,471	48	53	26.54	30.23	+ .07	25.6	−1.8	48	4	33	− 4	31	18	23	24	20	81		0.30	−1.2	8	4,384	se.	23	se.	8	4	7	20	7.3	2.2	T.
Boise	2,739	78	89	27.30	30.26	+ .05	23.6	−2.6	62	6	38	2	31	22	29	27	22	76		0.39	−1.3	7	2,927	se.	22	se.	9	6	10	15	6.6	2.2	1.0
Lewiston	737	40	48	28.36	30.19	+ .05	35.4	−1.1	57	4	43	7	31	30	23					0.45	−1.1	9	3,022	e.	28	s.	12	3	5	23	7.9	0.8	0.5
Pocatello	4,477	60	68	25.54	30.20	+ .01	27.7	−0.7	56	4	36	− 7	31	20	32	24	19	72		0.22	−0.6	5	6,664	se.	42	sw.	9	6	13	12	6.0	1.9	1.0
Spokane	1,929	101	110	28.07	30.18	+ .19	32.0	+1.2	55	3	37	5	31	27	18	30	26	78		0.89	−1.7	10	4,385	sw.	30	sw.	14	2	5	24	8.6	4.4	1.4
Walla Walla	991	57	65	24.10	30.29	+ .08	37.8	+1.8	67	4	43	13	31	32	25	34	29	75		1.48	−0.6	10	3,606	s.	27	se.	10	3	4	24	8.4	3.1	0.0
North Pacific Coast Region.							**42.0**	**−0.1**											**88**	**6.44**	**−1.3**									**7.6**		
North Head	211	11	56	29.87	30.08	+ .05	44.4	+0.1	52	3	48	31	23	41	13	43	41	90		7.81	+0.3	19	13,874	e.	78	se.	28	7	7	17	6.8	0.0	0.0
North Yakima	1,071	4																														
Port Angeles	23	8	53	30.07	30.10		39.7		53	13	45	27	31	34	19					6.29	+1.1	19	4,101	s.	32	sw.	28	1	4	26	8.6	T.	0.0
Seattle	125	215	250	29.09	30.12	+ .11	49.9	−0.3	58	4	45	27	24	36	14	40	37	86		5.04	−1.0	19	7,572	se.	42	s.	3	2	5	24	8.2	T.	0.0
Tacoma	213	113	120	29.88	30.12	+ .11	40.4	+0.1	60	4	46	25	31	35	17	40	38	91		7.29	0.0	18	4,604	sw.	31	sw.	28	1	4	25	8.6	T.	0.0
Tatoosh Island	86	7	57	29.93	30.03	+ .07	43.8	−0.1	52	4	47	34	31	41	14	42	40	85		12.24	−2.4	22	15,434	e.	68	s.	10	6	7	18	7.0	0.5	0.0
Medford	1,425	4																														
Portland, Oreg	153	68	105	29.98	30.14	+ .07	42.3	+1.0	61	3	47	25	31	38	15	41	39	87		3.13	−4.2	16	5,176	se.	28	sw.	2	7	8	16	7.0	0.0	0.0
Roseburg	510	9	57	29.61	30.17	+ .06	40.4	−4.5	59	13	46	19	31	34	22	38	36	85		3.28	−2.7	16	1,818	s.	22	w.	19	1	17	13	6.7	0.0	0.0
Middle Pacific Coast Region.							**46.2**	**−2.3**											**74**	**2.41**	**−2.0**									**4.0**		
Eureka	62	73	80	30.08	30.15	+ .03	46.3	−1.7	63	13	54	28	31	39	23	44	41	83		4.29	−3.0	14	4,470	se.	33	se.	8	13	7	11	4.8	0.0	0.0
Mount Tamalpais	2,375	11	18	27.09	30.11	− .01	43.2	−4.4	66	3	48	28	31	38	19	38	31	67		2.78	−1.1	9	13,921	nw.	70	se.	8	15	8	8	4.1	0.0	0.0
Point Reyes Light	490	7	18	29.54	30.06		50.6	0.0	68	3	56	38	31	46	17					1.29		9	12,831	nw.	85	nw.	26	15	8	8	4.0	0.0	0.0
Red Bluff	332	50	56	29.77	30.14	.00	44.2	−2.2	68	1	54	20	31	35	29	39	32	66		1.78	−2.7	5	4,401	n.	31	se.	8	17	7	7	3.9	0.0	0.0
Sacramento	69	105	117	30.05	30.13	− .01	43.4	−2.9	62	3	52	29	28	35	30	41	38	83		1.70	−1.8	4	5,072	se.	34	se.	8	18	7	6	3.8	0.0	0.0
San Francisco	155	209	213	29.94	30.11	− .01	50.2	−0.7	64	3	56	38	31	44	16	45	40	72		2.62	−1.6	7	4,692	ne.	37	ne.	20	18	8	5	3.1	0.0	0.0
San Jose	141	12	110	29.97	30.12		45.4	−4.5	68	4	56	27	31	34	33					1.28	−1.8	6	3,950	se.	35	n.	22	14	6	11	4.2	0.0	0.0
South Pacific Coast Region.							**52.0**	**−1.0**											**65**	**1.65**	**−0.5**									**3.0**		
Fresno	327	89	98	29.76	30.13	.00	45.0	−1.8	72	4	54	25	30	36	30	41	38	78		1.16	−0.1	4	3,155	e.	28	nw.	29	14	6	11	4.5	0.0	0.0
Los Angeles	338	159	191	29.65	30.03	− .04	57.2	+0.7	86	3	66	37	31	48	25	48	39	56		1.54	−1.4	3	4,628	ne.	24	nw.	29	21	5	5	2.5	0.0	0.0
San Diego	87	62	70	29.93	30.02	− .05	54.8	−0.9	78	3	64	35	31	46	28	48	41	63		1.68	−0.1	8	3,838	e.	35	w.	21	20	7	4	2.6	0.0	0.0
San Luis Obispo	201	32	49	29.86	30.03	− .02	51.0	−1.8	83	3	63	27	31	39	41	43	36	62		1.92	−0.4	6	2,964	n.	23	ne.	1	22	6	3	2.2	0.0	0.0
West Indies.																																
San Juan, P. R.	82	8	54	29.92	30.01		75.6		84	6	81	66	25	71	13					4.61	−1.5	26	9,143	ne.	40	ne.	21	9	16	6	5.1	0.0	0.0
Panama Canal.																																
Balboa Heights	118	7	97	29.70	29.82	− .02	81.0	+1.1	91	14	88	71	30	74	17	74	73	86		0.55	−3.7	5	6,986	n.	28	nw.	16	5	26	0	4.6		
Colon	36	30	97	29.89	29.84	− .02	80.6	+1.1	85	29	84	72	31	77	12	76	74	81		1.90	−9.8	19	11,269	n.	28	ne.	5	4	22	5	5.6		
Alaska.																																
Juneau	80	11	49				31.6		46	1	35	12	12	28	18	30	27	83		10.33		24	4,013	se.	27	ne.	13	2	5	24	8.5	40.1	0.5

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during December, 1918, at all stations furnished with self-registering gages.*

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Abilene, Tex.	19			0.77														0.31			
Albany, N. Y.	24			0.66														0.19			
Alpena, Mich.	21–22			0.65														(*)			
Amarillo, Tex.	22–23			0.86														(*)			
Anniston, Ala.	13–14	10:50 p. m.	2:30 p. m.	1.25	3:40 a. m.	4:14 a. m.	0.13	0.11	0.21	0.37	0.48	0.52	0.58	0.64							
Asheville, N. C.	22			1.29														0.47			
Atlanta, Ga.	21			2.76														0.44			
Atlantic City, N. J.	22			1.03														0.36			
Augusta, Ga.	24			0.47														0.33			
Baker, Oreg.	14			0.08														(*)			
Baltimore, Md.	14			0.65														0.35			
Bentonville, Ark.	8																				
Binghamton, N. Y.	14			0.11														0.06			
Birmingham, Ala.	13–14	8:49 p. m.	12:20 p. m.	1.65	11:24 p. m.	11:48 p. m.	0.12	0.29	0.44	0.53	0.64	0.69									
Bismarck, N. Dak.	29–30			0.49														(*)			
Block Island, R. I.	24			1.38														0.52			
Boise, Idaho.	20			0.16														(*)			
Boston, Mass.	15			0.34														0.26			
Buffalo, N. Y.	24–25			0.40														(*)			
Burlington, Vt.	24–25			0.52														(*)			
Cairo, Ill.	31			1.78														0.74			
Canton, N. Y.	22–23			0.42														(*)			
Charles City, Iowa.	9			0.38														(*)			
Charleston, S. C.	14			0.38														0.25			
Charlotte, N. C.	24			0.81														0.52			
Chattanooga, Tenn.	14			1.03														0.61			
Cheyenne, Wyo.	20–21			0.20														(*)			
Chicago, Ill.	9			0.69														0.28			
Cincinnati, Ohio.	9			1.22														0.38			
Cleveland, Ohio.	14			0.31														(*)			
Columbia, Mo.	23–24			0.83														(*)			
Columbia, S. C.	1			0.98														0.30			
Columbus, Ohio.	9			0.84														0.27			
Concord, N. H.	14–15			1.06														(*)			
Concordia, Kans.	20			0.58														0.18			
Corpus Christi, Tex.	13			0.57														0.51			
Dallas, Tex.	13			0.63														0.31			
Davenport, Iowa.	23–24			0.87														(*)			
Dayton, Ohio.	9			0.87														0.36			
Del Rio, Tex.	22			0.29														0.08			
Denver, Colo.	21–22			0.35														(*)			
Des Moines, Iowa.	31			0.44														(*)			
Detroit, Mich.	13–14			0.95														(*)			
Devils Lake, N. Dak.	29–30			0.34														(*)			
Dodge City, Kans.	22–23			1.35														(*)			
Drexel, Nebr.	20			0.36														0.18			
Dubuque, Iowa.	23–24			0.85														(*)			
Duluth, Minn.	9–10			0.55														(*)			
Eastport, Me.	14–15			0.47														(*)			
Elkins, W. Va.	9			1.02														0.25			
Ellendale, N. Dak.	20–21			0.29														(*)			
El Paso, Tex.	12			0.21														0.10			
Erie, Pa.	24–25			0.52														(*)			
Escanaba, Mich.	20–21			0.88														(*)			
Eureka, Cal.	8			1.01														0.27			
Evansville, Ind.	21			0.74														0.36			
Flagstaff, Ariz.	22			0.68														(*)			
Fort Smith, Ark.	12			1.13														0.30			
Fort Wayne, Ind.	20–21			1.71														(*)			
Fort Worth, Tex.	19			0.94														0.31			
Fresno, Cal.	8			0.46														0.23			
Galveston, Tex.	23	7:25 a. m.	10:43 a. m.	1.53	9:19 a. m.	10:32 a. m.	0.07	0.12†	0.32†	0.50†	0.68†	0.70†	0.72†	0.75†	0.84†	0.95†	1.08†	1.21	1.45		
Grand Haven, Mich.	10			0.51														0.24			
Grand Junction, Colo.	7			0.41														(*)			
Grand Rapids, Mich.	10			0.96														0.40			
Green Bay, Wis.	22–26			0.55														(*)			
Greenville, S. C.	16			2.11														0.50			
Hannibal, Mo.	20			0.23														0.11			
Harrisburg, Pa.	22			1.38														(*)			
Hartford, Conn.	14–15			0.82														0.24			
Hatteras, N. C.	15	D. N. a. m.	6:35 a. m.	1.37	3:04 a. m.	3:28 a. m.	0.55	0.05	0.20	0.41	0.55	0.62									
Havre, Mont.	29–30			0.07														(*)			
Helena, Mont.	31			0.04														(*)			
Houghton, Mich.	22			0.56														(*)			
Houston, Tex.	23			0.72														0.54			
Huron, S. Dak.	20–21			0.46														(*)			
Independence, Cal.	6			0.29														0.11			
Indianapolis, Ind.	9			0.57														0.44			
Iola, Kans.	20			0.57														0.20			
Jacksonville, Fla.	1			1.53														0.48			
Kalispell, Mont.	3			0.36														0.05			
Kansas City, Mo.	20			0.34														0.11			
Keokuk, Iowa.	23–24			0.98														(*)			
Key West, Fla.	15			1.08														0.40			
Knoxville, Tenn.	11			0.75														0.42			
La Crosse, Wis.	31			0.31														(*)			
Lander, Wyo.	29–30			0.50														(*)			
Lansing, Mich.	10			0.34														0.19			
Lewiston, Idaho.	8–9			0.09														0.05			
Lexington, Ky.	31			2.26														0.41			
Lincoln, Nebr.	20			0.56														(*)			
Little Rock, Ark.	31			4.46														0.55			
Los Angeles, Cal.	7			0.90														0.23			
Louisville, Ky.	12			0.93														0.33			
Ludington, Mich.	9–10			0.97														(*)			
Lynchburg, Va.	14			0.41														0.20			
Macon, Ga.	14	9:37 a. m.	3:24 p. m.	1.09	12:05 p. m.	12:34 p. m.	0.07	0.11	0.19	0.24	0.33	0.45	0.51								
Madison, Wis.	24			0.75														(*)			
Marquette, Mich.	5			0.58														(*)			

*Self-register not in use.

†Record partly estimated.

TABLE II.—*Accumulated amounts of precipitation for each 5 minutes, for the principal storms in which the rate of fall equaled or exceeded 0.25 inch in any 5 minutes, or 0.80 in 1 hour, during December, 1918, at all stations furnished with self-registering gages*—Continued.

Stations.	Date.	Total duration.		Total amount of precipitation.	Excessive rate.		Amount before excessive rate began.	Depths of precipitation (in inches) during periods of time indicated.												
		From—	To—		Began—	Ended—		5 min.	10 min.	15 min.	20 min.	25 min.	30 min.	35 min.	40 min.	45 min.	50 min.	60 min.	80 min.	100 min.	120 min.
Memphis, Tenn	31			2.77																	
Meridian, Miss	23			0.92														0.59			
Miami, Fla	1	7:22 p. m.	D. N. p. m.	1.64	8:04 p. m.	8:44 p. m.	0.14	0.18	0.29	0.37	0.45	0.64	0.90	1.26	1.49			0.56			
Milwaukee, Wis	24			0.81														(*)			
Minneapolis, Minn	20–21			0.56														(*)			
Mobile, Ala	21			2.03														0.61			
Modena, Utah	7			1.48														0.24			
Montgomery, Ala	14			1.04														0.63			
Moorhead, Minn	29–30			0.40														(*)			
Mount Tamalpais, Cal	20			0.65														0.27			
Nantucket, Mass	25			0.39														0.31			
Nashville, Tenn	31			1.84														0.43			
New Haven, Conn	22			1.32														0.54			
New Orleans, La	10			1.56														0.78			
New York, N. Y	22			1.15														0.30			
Norfolk, Va	15			0.86														0.17			
Northfield, Vt	24–25			0.87														(*)			
North Head, Wash	2			1.44														0.24			
North Platte, Nebr	19–20			0.39														(*)			
Oklahoma, Okla	23			1.25														(*)			
Omaha, Nebr	23–34			0.22														(*)			
Oswego, N. Y	22–23			0.62														(*)			
Palestine, Tex	23			0.68														0.45			
Parkersburg, W. Va	10			0.57														0.37			
Pensacola, Fla	21			1.97														0.64			
Peoria, Ill	23–24			1.02														(*)			
Philadelphia, Pa	15			0.74														0.36			
Phoenix, Ariz	21			0.48														0.15			
Pierre, S. Dak	20–21			0.67														(*)			
Pittsburgh, Pa	9			0.40														0.28			
Pocatello, Idaho	29			0.10														(*)			
Point Reyes Light, Cal	8			0.29														0.20			
Port Angeles, Wash	3			2.37														0.32			
Port Huron, Mich	13–14			0.76														(*)			
Portland, Me	22–23			0.75														(*)			
Portland, Oreg	19			0.76														0.20			
Providence, R. I	24–25			0.85														(*)			
Pueblo, Colo	16–17			0.30														(*)			
Raleigh, N. C	22			0.64														0.21			
Rapid City, S. Dak	20–21			0.26														(*)			
Reading, Pa	22			1.90														0.37			
Red Bluff, Cal	20			0.40														0.18			
Reno, Nev	7			0.16														(*)			
Richmond, Va	22			0.99														0.37			
Rochester, N. Y	5–6			0.63														(*)			
Roseburg, Oreg	19			0.47														0.24			
Roswell, N. Mex	22			0.37														(*)			
Sacramento, Cal	8			0.43														0.25			
Saginaw, Mich	21			0.72														0.09			
St. Joseph, Mo	12–13			0.65														(*)			
St. Louis, Mo	21			0.22														0.21			
St. Paul, Minn	9–10			0.49														(*)			
Salt Lake City, Utah	9			0.26														(*)			
San Antonio, Tex	23	12:42 a. m.	4:22 a. m.	0.77	3:45 a. m.	4:04 a. m.	0.12	0.08	0.23	0.52	0.64										
San Diego, Cal	7	5:20 p. m.	6:25 p. m.	0.56	5:25 p. m.	5:55 p. m.	T.	0.29	0.38	0.43	0.47	0.50	0.52								
Sand Key, Fla																					
Sandusky, Ohio	10			0.35														0.26			
Sandy Hook, N. J	15			0.49														0.37			
San Francisco, Cal	8			0.65														0.38			
San Jose, Cal	8			0.35														0.16			
San Luis Obispo, Cal	8			0.53														0.20			
Santa Fe, N. Mex	16			0.28														(*)			
Sault Ste. Marie, Mich	20–21			0.90														(*)			
Savannah, Ga	22			0.67														0.35			
Scranton, Pa	22			0.74														(*)			
Seattle, Wash	13			0.88														0.18			
Sheridan, Wyo	29			0.08														(*)			
Shreveport, La	23	7:25 a. m.	12:10 p. m.	1.16	10:11 a. m.	10:39 a. m.	0.52	0.09	0.18	0.40	0.50	0.56	0.89								
Sioux City, Iowa	8–9			0.60																	
Spokane, Wash	19–20			0.29														(*)			
Springfield, Ill	23–24			0.75														(*)			
Springfield, Mo	12–13			1.29														(*)			
Syracuse, N. Y	5–6			0.56														(*)			
Tacoma, Wash	13			1.97														0.29			
Tampa, Fla	1			0.63														0.54			
Tatoosh Island, Wash	3			2.98														0.51			
Taylor, Tex	12–13	9:00 p. m.	D. N. a. m.	1.30	11:27 p. m.	12:06 a. m.	0.02	0.10	0.23	0.34	0.47	0.53	0.56	0.64	0.72						
Terre Haute, Ind	9			0.41														0.33			
Thomasville, Ga	21–22	4:45 p. m.	D. N. a. m.	3.26	9:16 p. m.	10:30 p. m.	0.64	0.08	0.14	0.30	0.34	0.38	0.45	0.53	0.63	0.67	0.72	0.98	1.28		
					12:10 a. m.	1:00 a. m.	2.19	0.09	0.20	0.26	0.34	0.39	0.43	0.49	0.59	0.67	0.82				
Toledo, Ohio	12–13			0.72														(*)			
Tonopah, Nev																					
Topeka, Kans	20			0.32														0.14			
Trenton, N. J	15			0.65														0.36			
Valentine, Nebr	8–9			0.35														(*)			
Vicksburg, Miss	21			2.06														0.72			
Walla Walla, Wash	14			0.56														(*)			
Washington, D. C	14			1.47														0.59			
Wausau, Wis	9–10			0.28														(*)			
Wichita, Kans	23			1.44														(*)			
Williston, N. Dak	29–30			0.74														(*)			
Wilmington, N. C	22			1.20														0.50			
Winnemucca, Nev	7			0.26														0.04			
Wytheville, Va	22			0.62														0.37			
Yankton, S. Dak	20–21			0.42														(*)			
Yellowstone Park, Wyo	29			0.10														(*)			

* Self-register not in use.

TABLE III.—*Data furnished by the Canadian Meteorological Service, December, 1918.*

Stations.	Altitude above M. S. L., Jan. 1, 1916.	Pressure.			Temperature.						Precipitation.		
		Station reduced to mean of 24 hours.	Sea level reduced to mean of 24 hours.	Departure from normal.	Mean max.+ mean min.÷ 2.	Departure from normal.	Mean maximum.	Mean minimum.	Highest.	Lowest.	Total.	Departure from normal.	Total snowfall.
	Feet.	*Inches.*	*Inches.*	*Inches.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	° *F.*	*Inches.*	*Inches.*	*Inches.*
St. Johns, N. F.	125	29.74	29.88	+0.05	26.6	−2.1	31.9	21.4	45	7	3.31	−1.72	23.0
Sydney, C. B. I.	48	29.99	30.03	+ .14	28.8	+0.6	34.0	23.6	49	16	5.03	+0.40	29.5
Halifax, N. S.	88	29.96	30.07	+ .11	29.2	+1.6	35.7	22.6	51	3	6.25	+1.13	24.3
Yarmouth, N. S.	65	29.98	30.05	+ .07	31.3	+0.6	36.8	25.8	50	17	5.23	+0.19	19.2
Charlottetown, P. E. I.	38	30.00	30.04	+ .10	26.0	+1.7	30.2	21.8	45	8	4.08	+0.42	26.2
Chatham, N. B.	28	30.08	30.11	+ .17	19.8	+2.8	26.9	12.7	47	− 9	3.36	+0.14	23.0
Father Point, Que.	20	30.11	30.14	+ .19	18.0	+2.6	24.0	12.0	44	− 5	1.72	−1.11	11.7
Quebec, Que.	296	29.79	30.14	+ .13	18.8	+3.6	24.4	13.3	43	− 7	4.39	+0.70	24.9
Montreal, Que.	187	29.92	30.14	+ .11	22.1	+3.8	27.5	16.7	47	− 3	3.72	+0.07	18.4
Stonecliffe, Ont.	489	29.48	30.11	+ .10	16.3	+1.3	24.8	7.8	40	−16	2.46	−0.03	16.4
Ottawa, Ont.	236	29.86	30.15	+ .13	20.6	+3.6	27.5	13.6	46	− 4	3.89	+0.98	24.2
Kingston, Ont.	285	29.79	30.12	+ .08	26.9	+3.2	33.9	20.0	48	4	2.76	−0.48	11.9
Toronto, Ont.	379	29.66	30.09	+ .04	31.3	+4.3	37.2	25.4	51	14	3.30	+0.39	16.0
White River, Ont.	1,244	28.68	30.05	+ .08	13.1	+3.4	22.5	3.7	39	−30	2.17	+0.46	16.5
Port Stanley, Ont.	592	29.42	30.08	+ .01	33.3	+4.9	39.7	27.0	51	17	3.12	+0.70	5.6
Southampton, Ont.	656	29.32	.....	.....	30.3	+3.6	35.8	24.8	51	13	3.87	−0.11	21.7
Parry Sound, Ont.	688	29.36	30.08	+ .07	25.0	+3.8	32.1	17.9	48	0	3.67	−0.81	16.4
Port Arthur, Ont.	644	29.34	30.07	+ .08	20.2	+7.0	28.5	12.0	39	− 8	1.21	+0.34	10.2
Winnipeg, Man.	760	29.21	30.09	+ .07	13.3	+9.2	20.7	5.9	40	−24	1.31	+0.40	13.1
Minnedosa, Man.	1,690	28.16	30.08	+ .06	11.3	+5.6	19.2	3.4	34	−37	0.53	−0.09	5.3
Qu'Appelle, Sask.	2,115	27.67	30.02	+ .02	15.7	+8.3	22.9	8.4	39	−28	0.71	+0.19	7.1
Medicine Hat, Alberta.	2,144	27.61	29.96	− .01	25.6	+7.4	35.2	16.1	35	16	0.58	+0.03	5.8
Swift Current, Sask.	2,392	27.33	30.00	+ .01	21.6	+5.6	30.3	13.0	48	−26	1.01	+0.23	10.1
Calgary, Alberta.	3,428	26.34	29.99	+ .05	24.0	+5.8	34.9	13.2	52	− 4	0.82	+0.23	8.2
Banff, Alberta.	4,521	25.32	30.09	+ .15	18.8	−0.3	26.0	11.6	38	−15	2.77	+1.56	27.7
Edmonton, Alberta.	2,150	27.57	29.93	.00	20.0	+6.9	28.5	11.6	45	0	1.65	+0.95	16.5
Prince Albert, Sask.	1,450	28.40	30.03	+ .02	14.0	+11.2	23.8	4.2	44	−23	0.59	−0.15	4.8
Battleford, Sask.	1,592	28.19	30.00	+ .01	15.6	+10.2	25.7	5.5	45	−27	0.63	+0.31	6.3
Kamloops, B. C.	1,262	28.85	30.18	+ .24	29.1	+ 0.2	33.7	24.6	46	9	0.91	+0.13	8.5
Victoria, B. C.	230	29.81	30.07	+ .10	40.8	− 0.4	44.6	37.1	51	30	7.15	−0.83	T.
Barkerville, B. C.	4,180	25.59	30.01	+ .13	20.6	− 0.3	26.3	14.9	37	− 6	3.90	+0.73	39.0
Hamilton, Bermuda.	151	30.00	30.17	+ .05	64.8	+ 0.1	70.0	59.5	75	52	4.18	−0.31	.....

Chart I. Hydrographs of Several Principal Rivers, December, 1918.

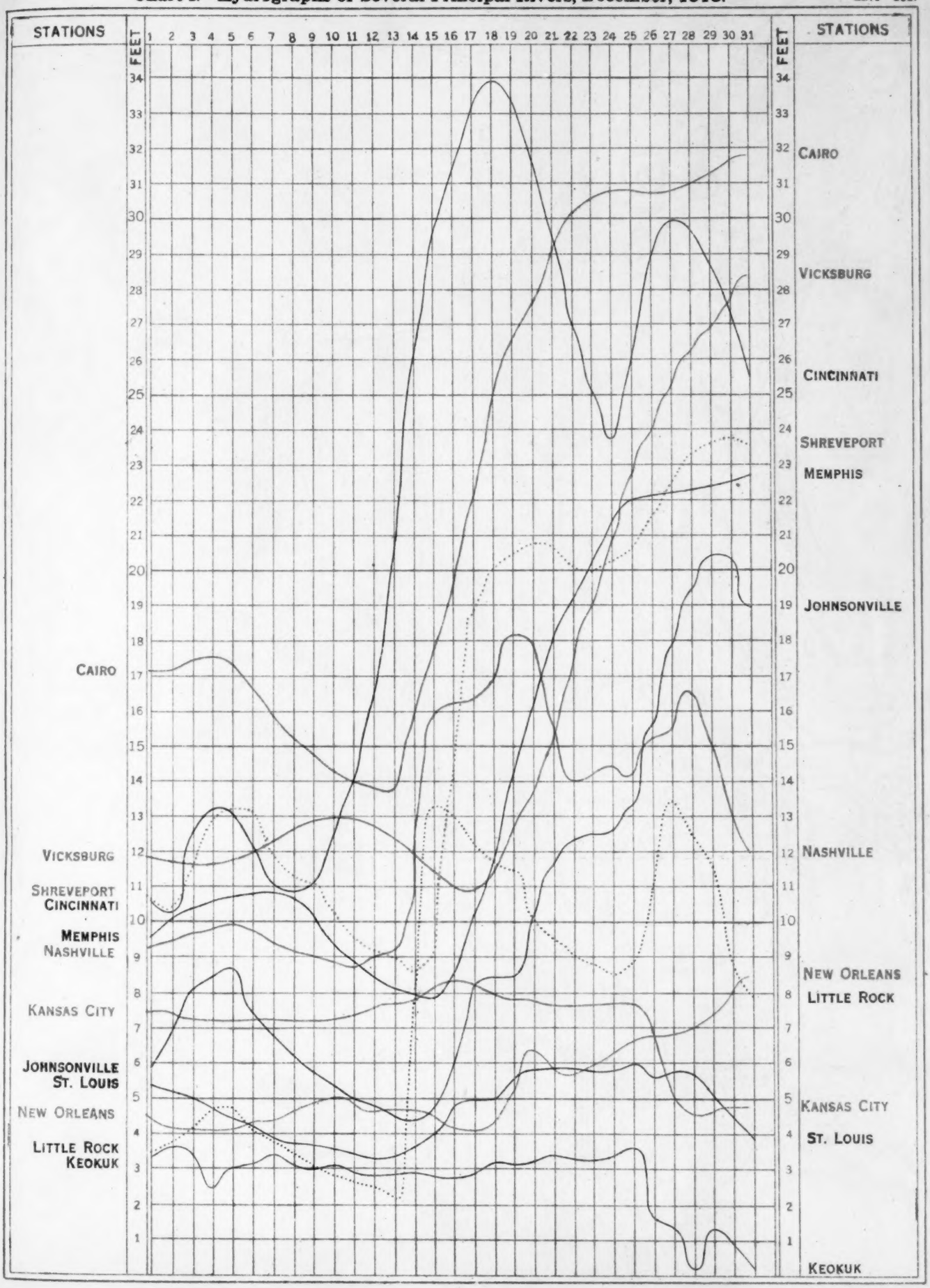


Chart II. Tracks of Centers of High Areas, December, 1918.

(Plotted by Charles A. Donnel.)

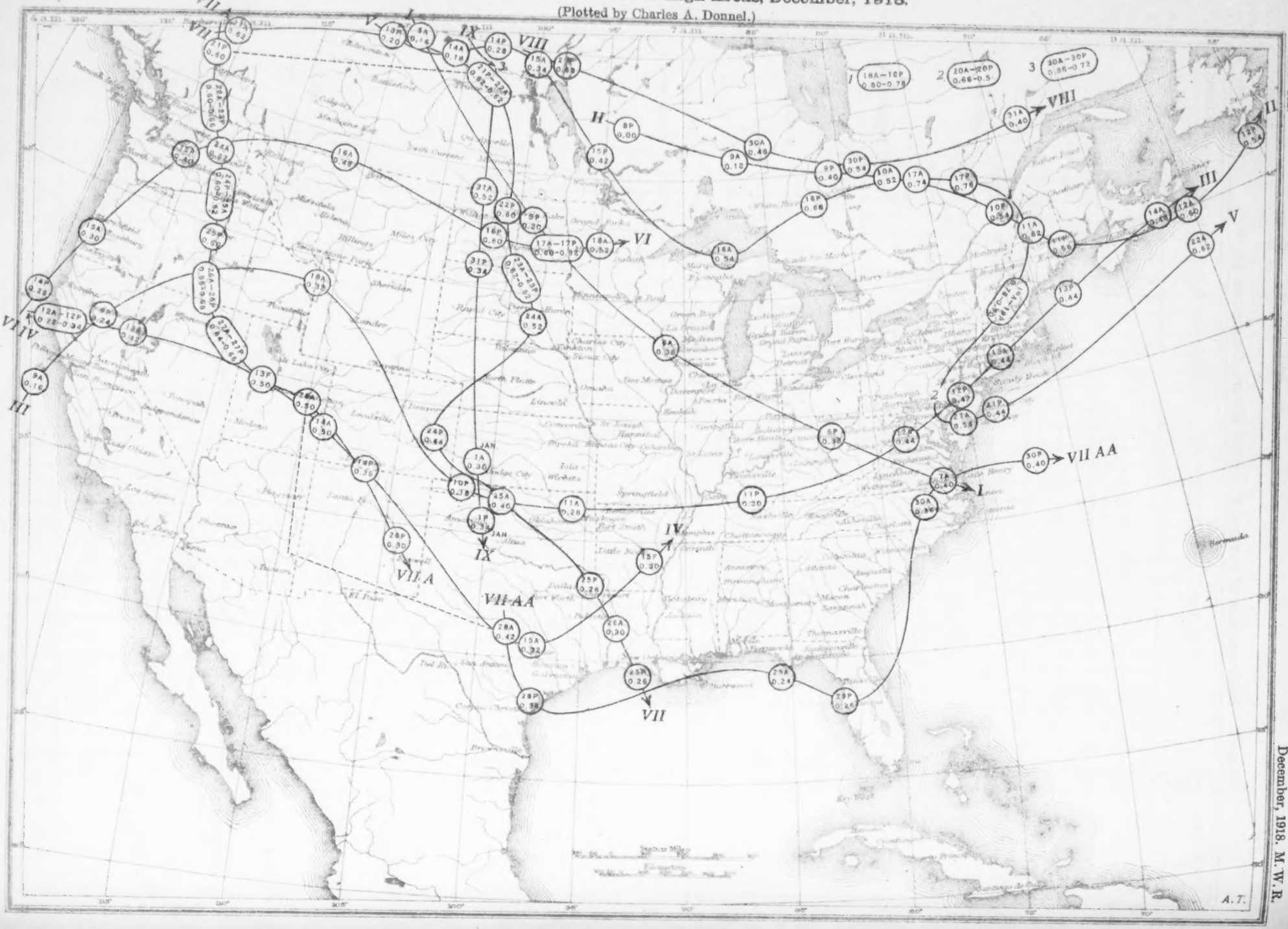


Chart III. Tracks of Centers of Low Areas, December, 1918

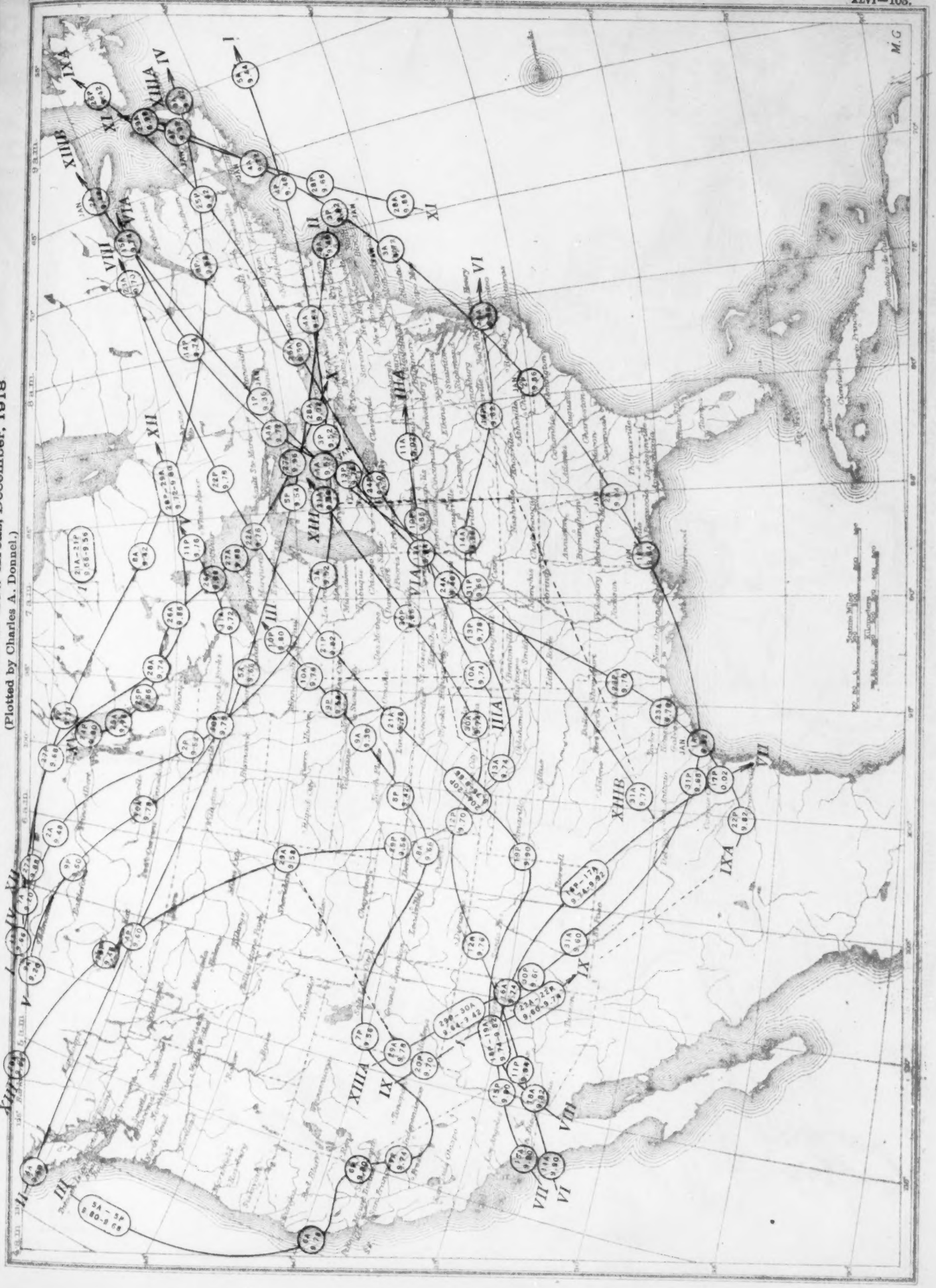


Chart III. Tracks of Centers of Low Areas, December, 1918
(Plotted by Charles A. Donnel.)

Chart IV. Departure (°F.) of the Mean Temperature from the Normal, December, 1918.

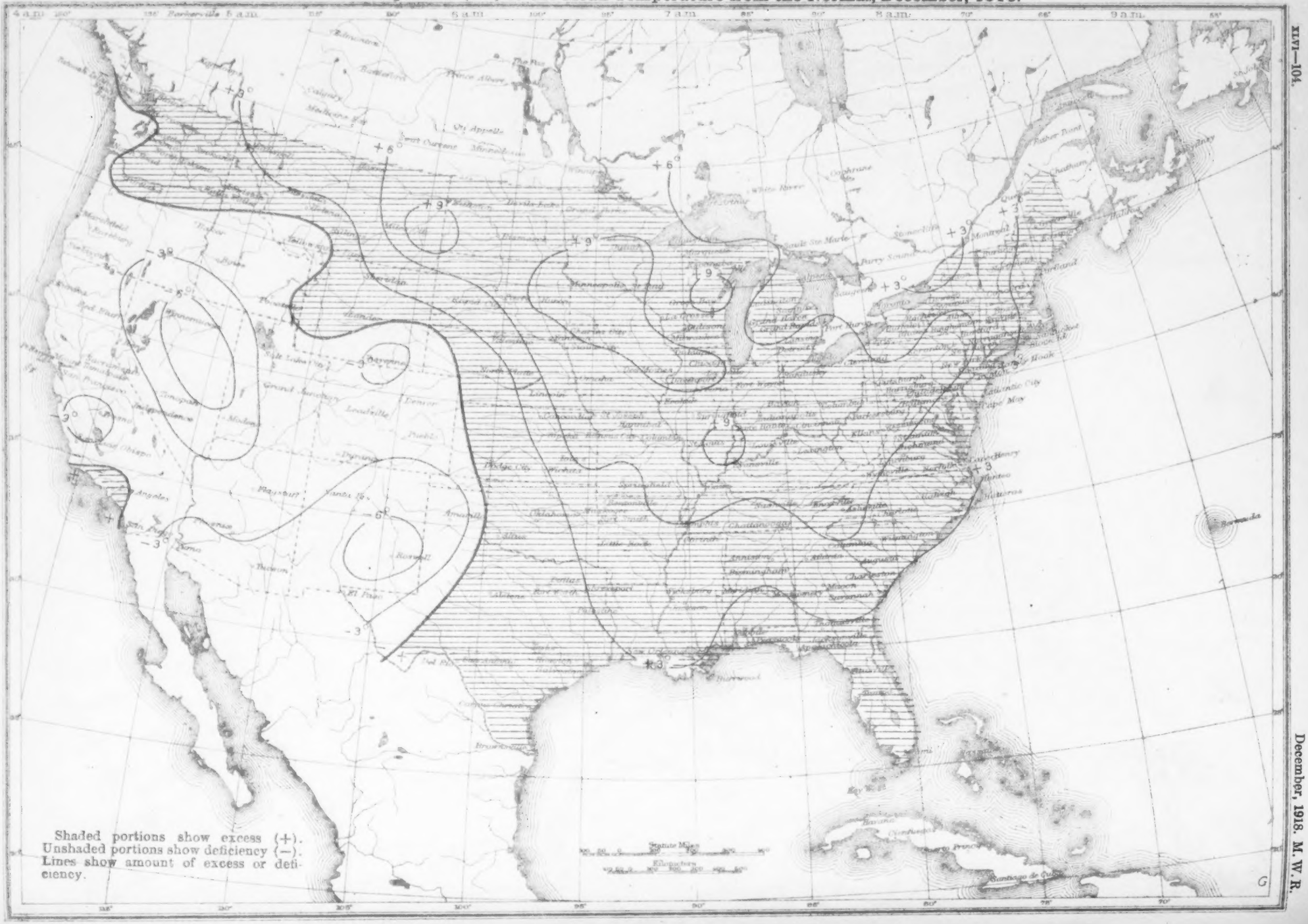


Chart V. Total Precipitation, Inches, December, 1918.

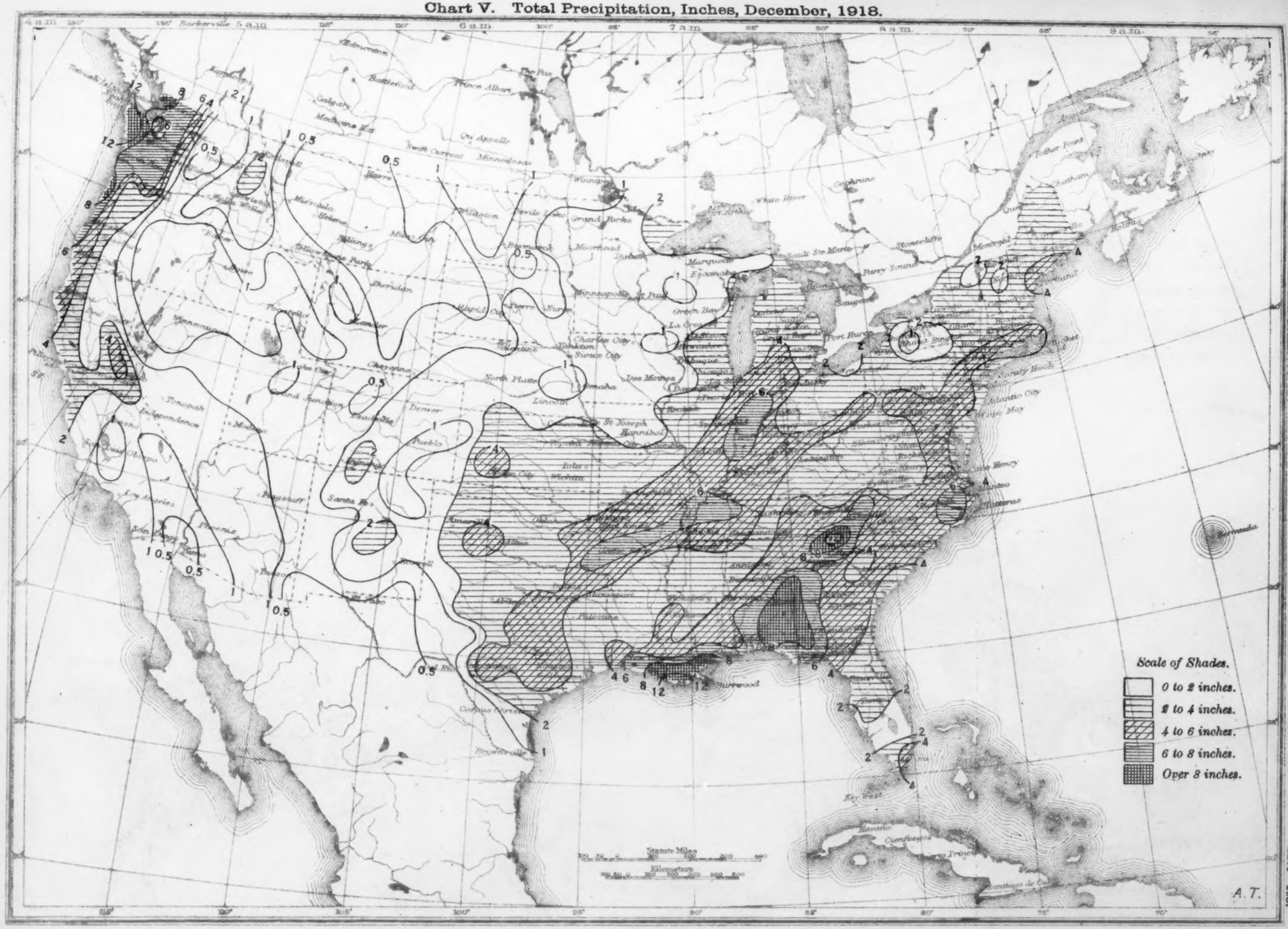


Chart VI. Percentage of Clear Sky between Sunrise and Sunset, December, 1918.

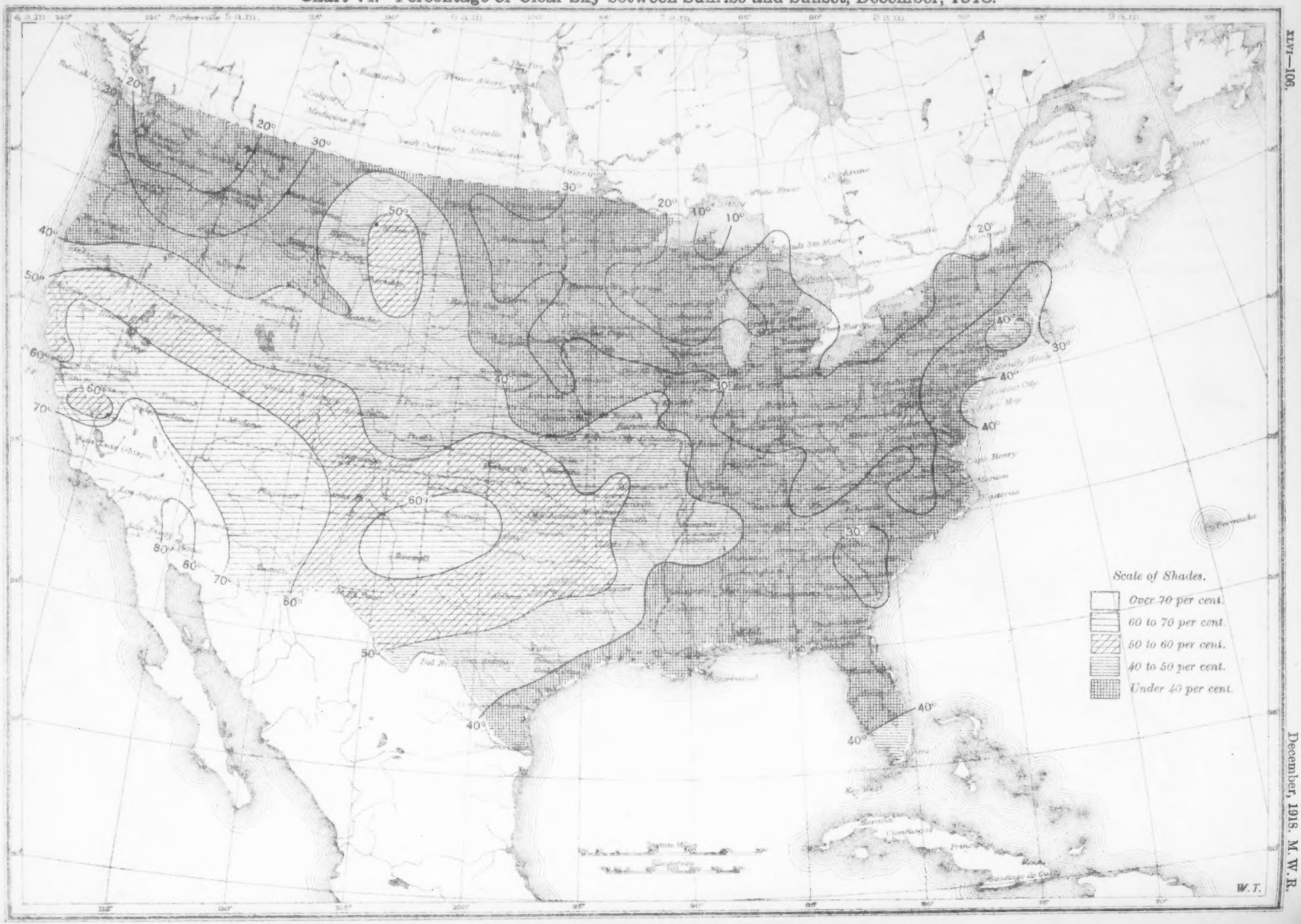


Chart VII. Isobars and Isotherms at Sealevel; Prevailing Winds, December, 1918.

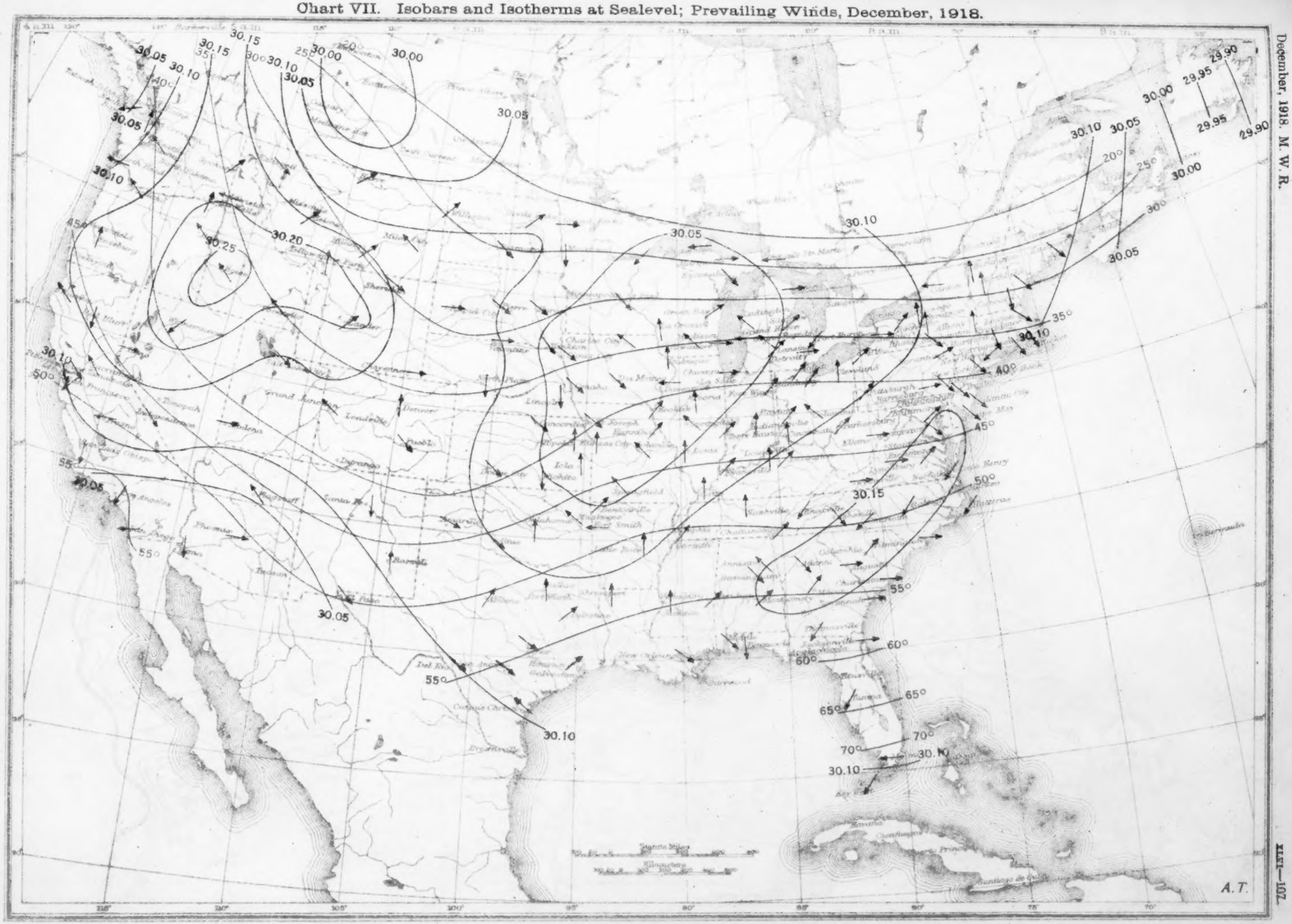


Chart VIII. Total Snowfall, Inches, December, 1918.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, December, 1917.

Chart IX. Means of Meteorological Data for North Atlantic Ocean, December, 1917.

(Plotted by F. A. Young.)

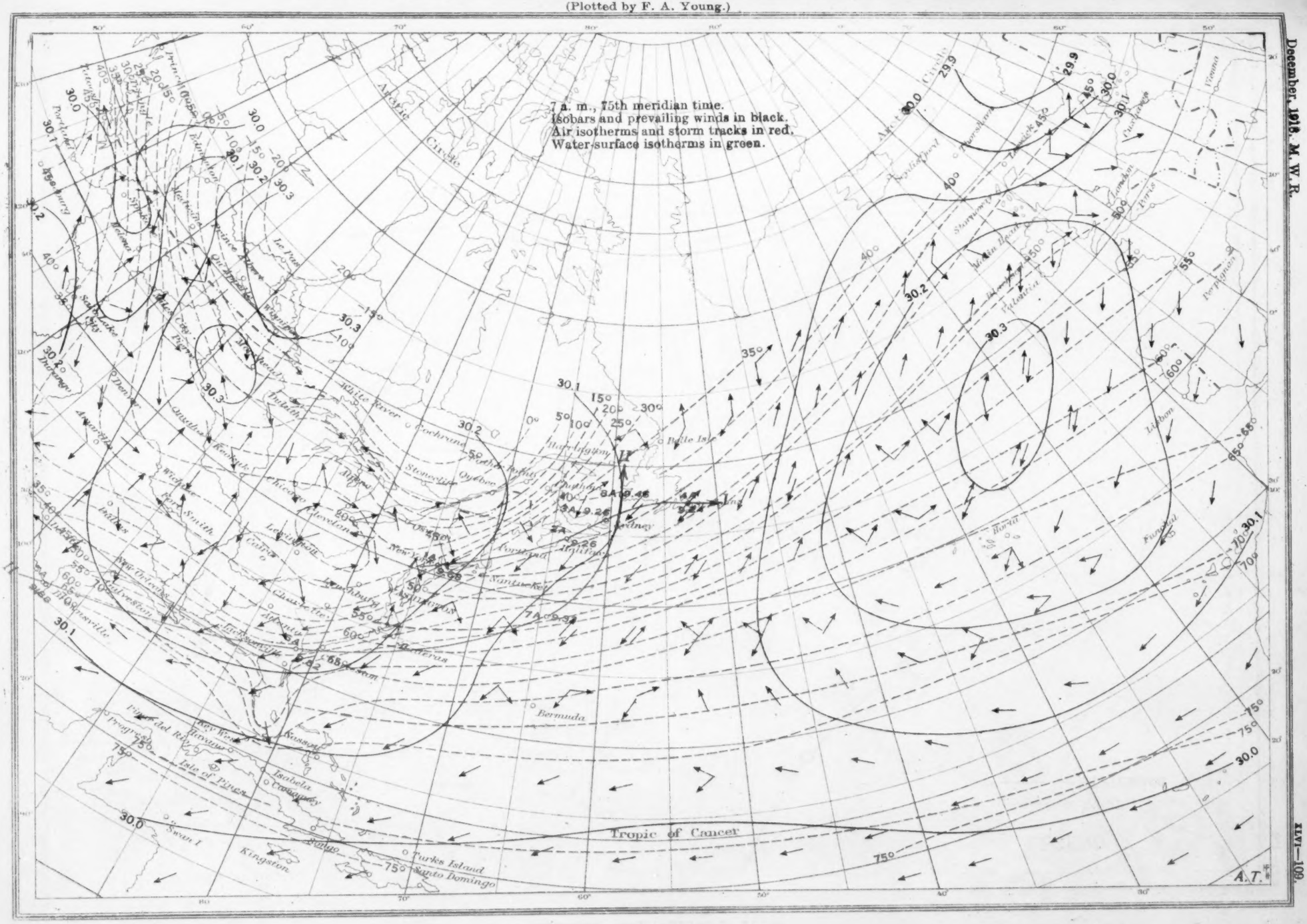
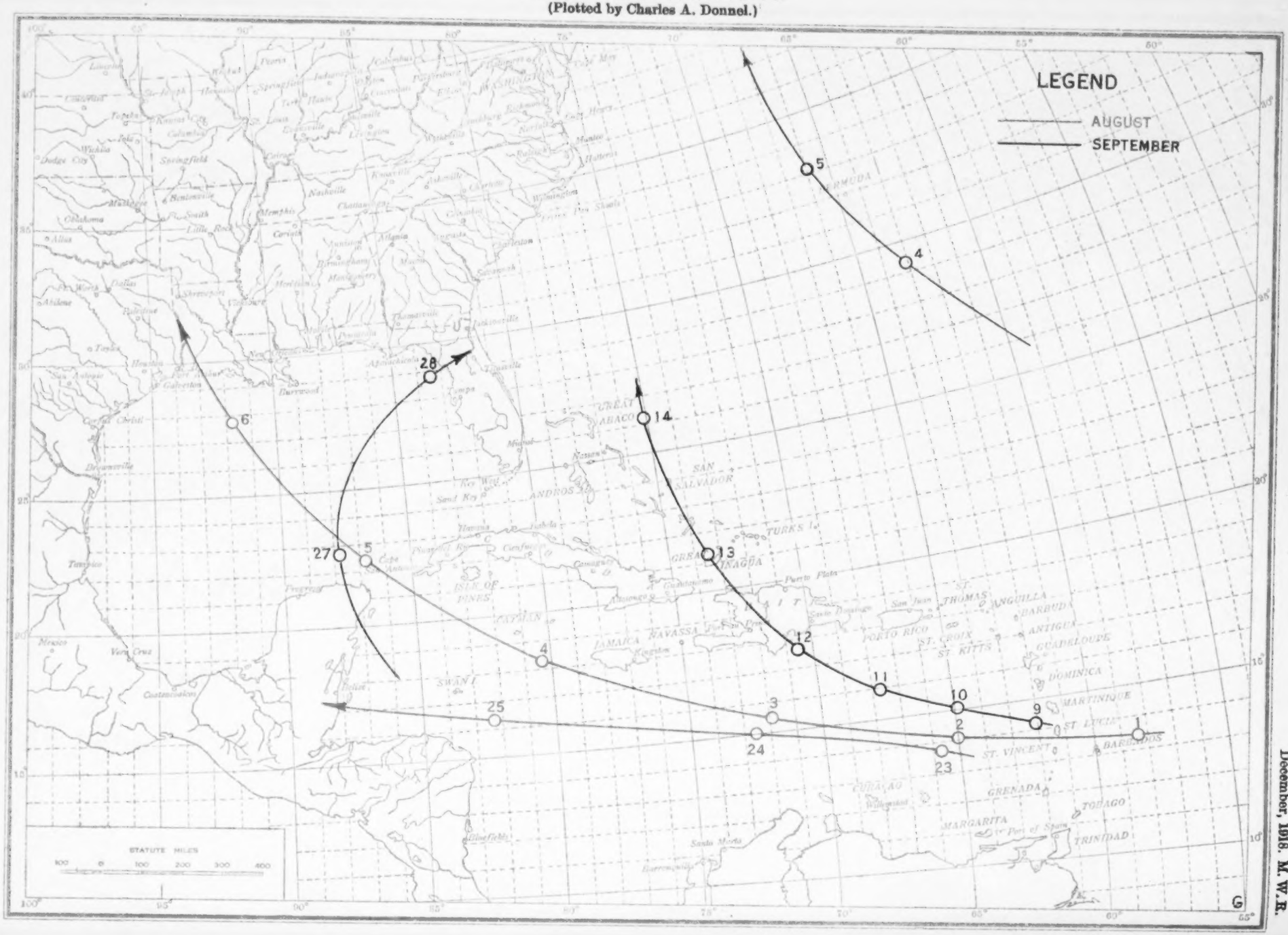


Chart X. Hurricanes of 1918.

(Plotted by Charles A. Donnel.)


LEGEND
AUGUST
SEPTEMBER
STATUTE MILES
100 0 100 200 300 400
BERMUDA
GREAT ABACO
SAN SALVADOR
ANDROS I.
TURKS I.
GREAT INAGUA
CUBA
JAMAICA
NAVASSA
HAITI
PORTO RICO
ISLE OF PINES
CAYMAN IS.
SWAN I.
ST. THOMAS
ANGUILLA
BARBUDA
ANTIGUA
GUADELOUPE
DOMINICA
MARTINIQUE
ST. LUCIA
BARBADOS
ST. VINCENT
GRENADA
TOBAGO
TRINIDAD
MARGARITA
CURAÇAO
Key West
Tampico
Vera Cruz
Progreso
Belize
Bluefields
Santa Marta
Port of Spain
Porto Plata
Guantanamo
Habana
Nassau
Galveston
Corpus Christi
Brownsville
Dodge City
Oklahoma
Dallas
Abilene
Memphis
Nashville
Atlanta
Birmingham
Montgomery
Jacksonville
Charleston
Wilmington
Hatteras
Cape Fear
Washington
Baltimore
Philadelphia
New York
Boston
Portland
Buffalo
Cleveland
Detroit
Chicago
Milwaukee
Omaha
Kansas City
Denver
Cheyenne
Salt Lake City
Pueblo
Santa Fe
El Paso
Phoenix
Los Angeles
San Francisco
Portland
Seattle
Spokane
Helena
Bismarck
Minneapolis
St. Paul
Duluth
Winnipeg
Moorhead
Fargo
Huron
Sioux Falls
Des Moines
St. Louis
Springfield
Little Rock
Shreveport
Houston
San Antonio
Wichita
Topeka
Columbia
Louisville
Cincinnati
Indianapolis
Toledo
Pittsburgh
Erie
Buffalo
Albany
Syracuse
Rochester
Scranton
Harrisburg
Atlantic City
Norfolk
Richmond
Raleigh
Greensboro
Knoxville
Chattanooga
Mobile
New Orleans
Jacksonville
Tallahassee
Pensacola
Savannah
Charleston
Wilmington
Cape Hatteras
Cape Lookout
Cape Fear
Key West
Havana
Isabela
Cienfuegos
Cape Antonio
Camagüey
Guantanamo
Santiago
Port au Prince
Kingston
Montego Bay
Puerto Plata
Santo Domingo
San Juan
Ponce
Mayaguez
Willemstad
Maracaibo
Puerto Cabello
La Guaira
Caracas
Barranquilla
Cartagena
Colon
Panama
Puerto Limon
Belize
Progreso
Campeche
Veracruz
Tampico
Matamoros
Monterrey
Saltillo
Torreon
Durango
Mazatlan
Guaymas
Hermosillo
Nogales
Tucson
Yuma
San Diego
Los Angeles
San Francisco
Sacramento
Reno
Carson City
Virginia City
Salt Lake City
Ogden
Provo
Grand Junction
Colorado Springs
Pueblo
Denver
Cheyenne
Laramie
Rawlins
Rock Springs
Evanston
Green River
Vernal
Price
Moab
Durango
Silverton
Telluride
Montrose
Gunnison
Leadville
Aspen
Glenwood Springs
Steamboat Springs
Craig
Meeker
Rangely
Dinosaur
Maybell
Baggs
Encampment
Saratoga
Laramie
Cheyenne
Fort Collins
Greeley
Boulder
Denver
Colorado Springs
Pueblo
Trinidad
Raton
Las Vegas
Santa Fe
Albuquerque
Gallup
Grants
Socorro
Las Cruces
El Paso
Alpine
Marfa
Presidio
Del Rio
Eagle Pass
Laredo
Brownsville
Corpus Christi
Galveston
Houston
Beaumont
Port Arthur
Lake Charles
New Orleans
Baton Rouge
Lafayette
Shreveport
Texarkana
Fort Smith
Little Rock
Pine Bluff
Hot Springs
Memphis
Jackson
Vicksburg
Meridian
Tuscaloosa
Birmingham
Anniston
Montgomery
Selma
Mobile
Pensacola
Tallahassee
Jacksonville
Daytona Beach
Orlando
Tampa
St. Petersburg
Sarasota
Fort Myers
Naples
Key West
Miami
West Palm Beach
Fort Pierce
Vero Beach
Melbourne
Cocoa
Titusville
Daytona Beach
St. Augustine
Jacksonville
Fernandina
Brunswick
Savannah
Charleston
Georgetown
Myrtle Beach
Wilmington
New Bern
Cape Hatteras
Cape Lookout
Cape Fear
Norfolk
Virginia Beach
Richmond
Petersburg
Lynchburg
Roanoke
Bristol
Johnson City
Kingsport
Knoxville
Chattanooga
Nashville
Clarksville
Hopkinsville
Paducah
Cairo
Evansville
Indianapolis
Terre Haute
Lafayette
Logansport
South Bend
Gary
Chicago
Milwaukee
Racine
Kenosha
Waukegan
Rockford
Freeport
Dubuque
Davenport
Rock Island
Moline
Peoria
Bloomington
Springfield
Decatur
Champaign
Danville
Terre Haute
Evansville
Owensboro
Louisville
Lexington
Frankfort
Ashland
Huntington
Charleston
Parkersburg
Clarksburg
Fairmont
Morgantown
Uniontown
Pittsburgh
Johnstown
Altoona
Harrisburg
Lancaster
Reading
Allentown
Bethlehem
Easton
Trenton
Atlantic City
Cape May
Wilmington
Dover
Salisbury
Ocean City
Cape Charles

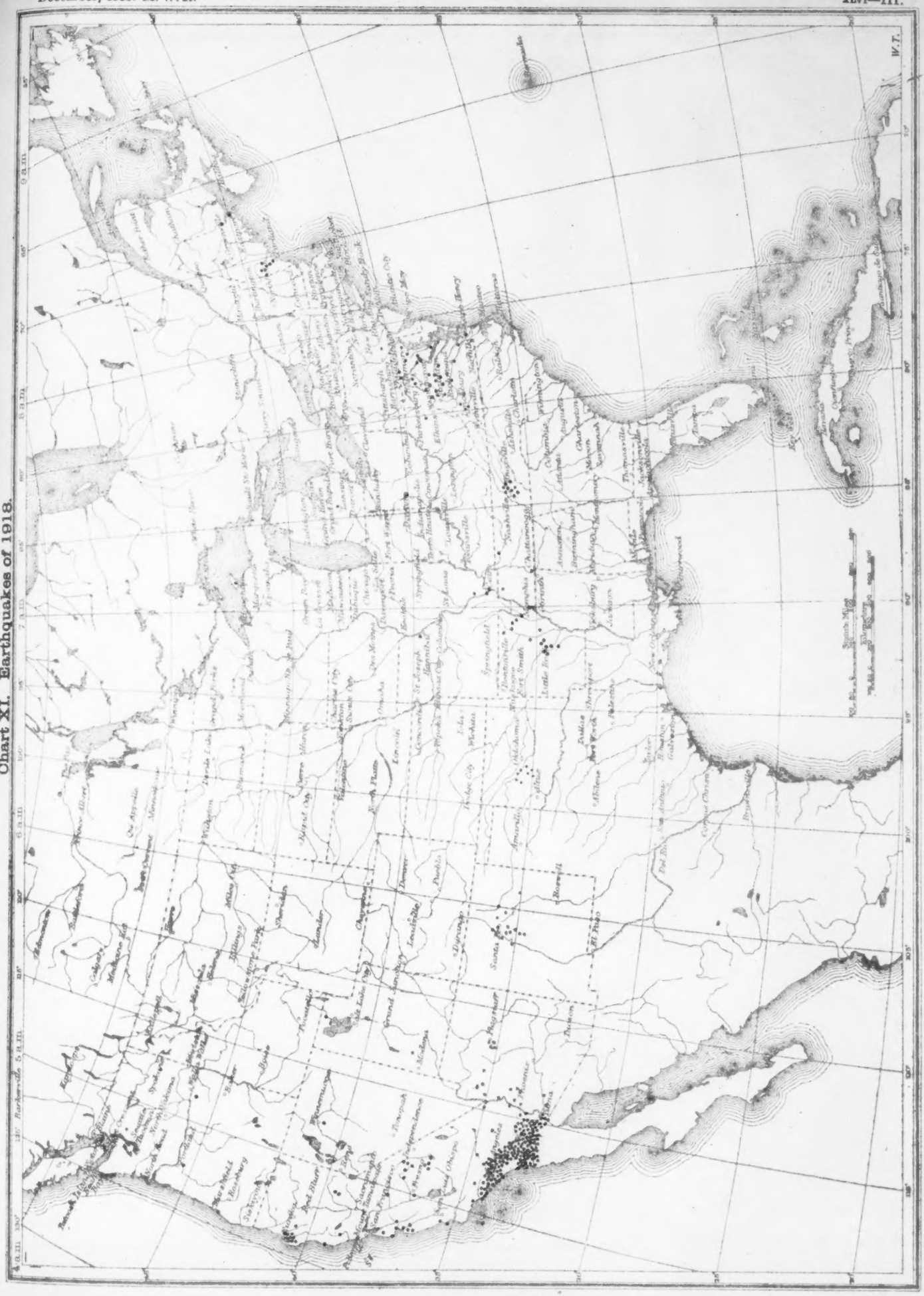
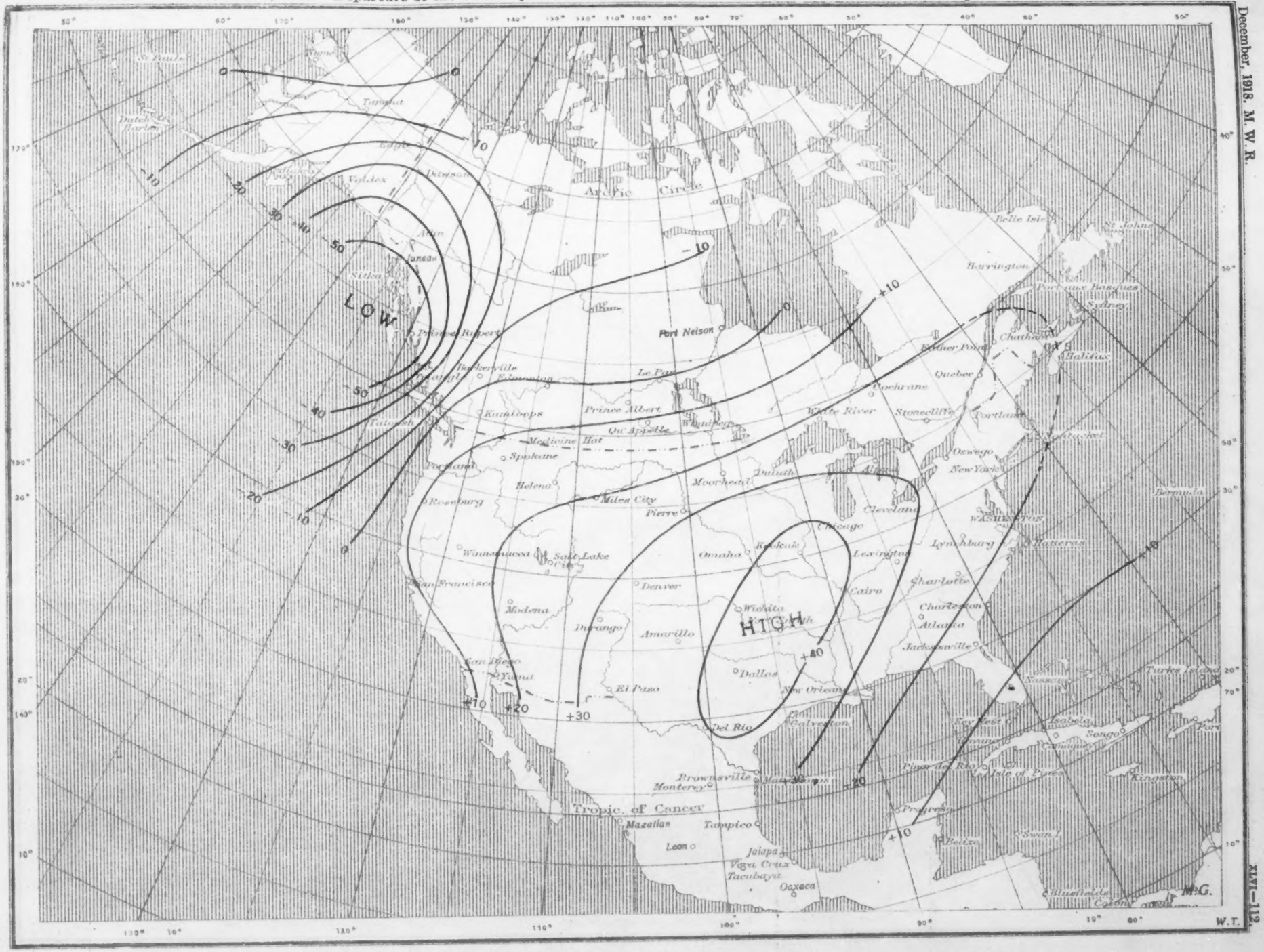
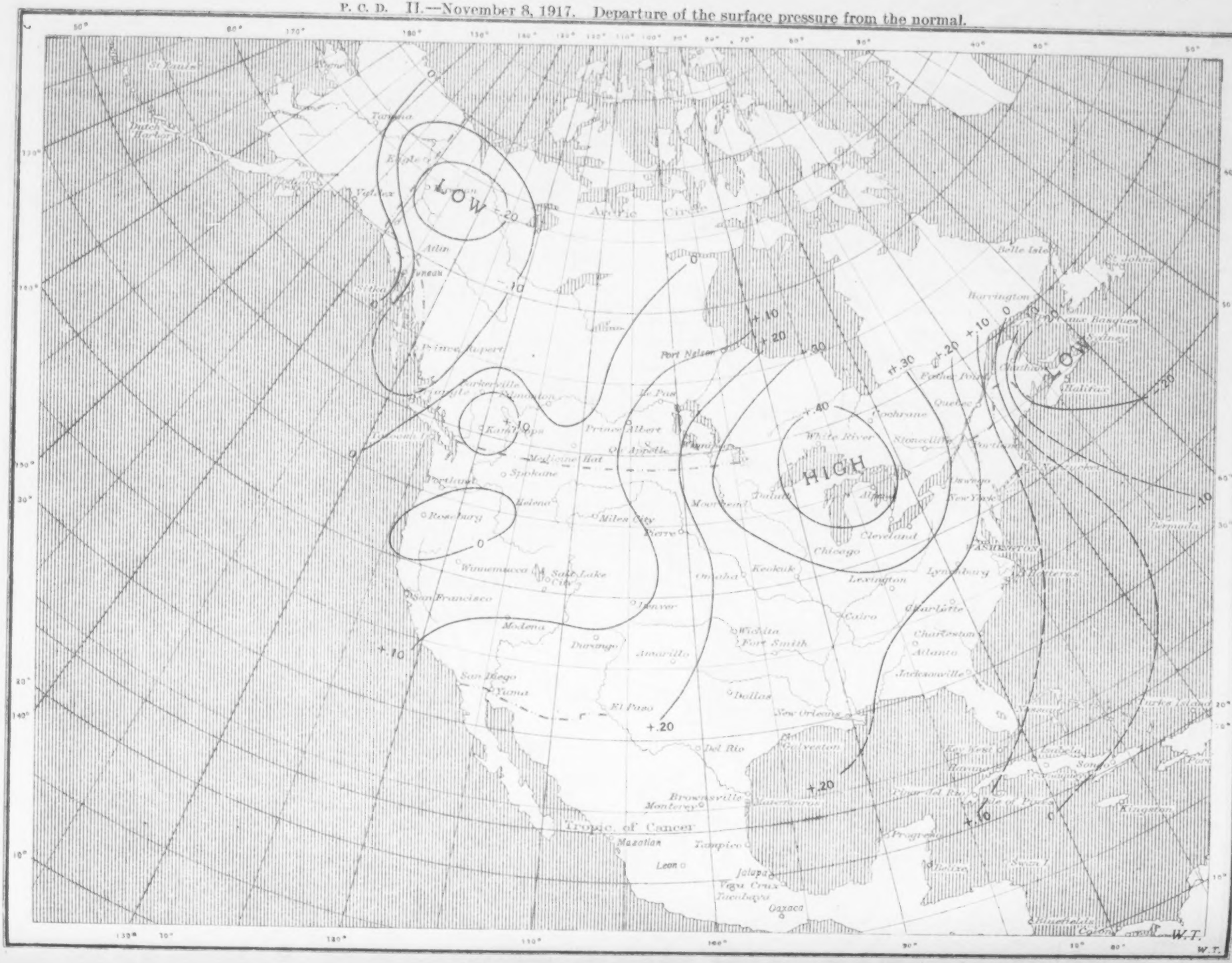


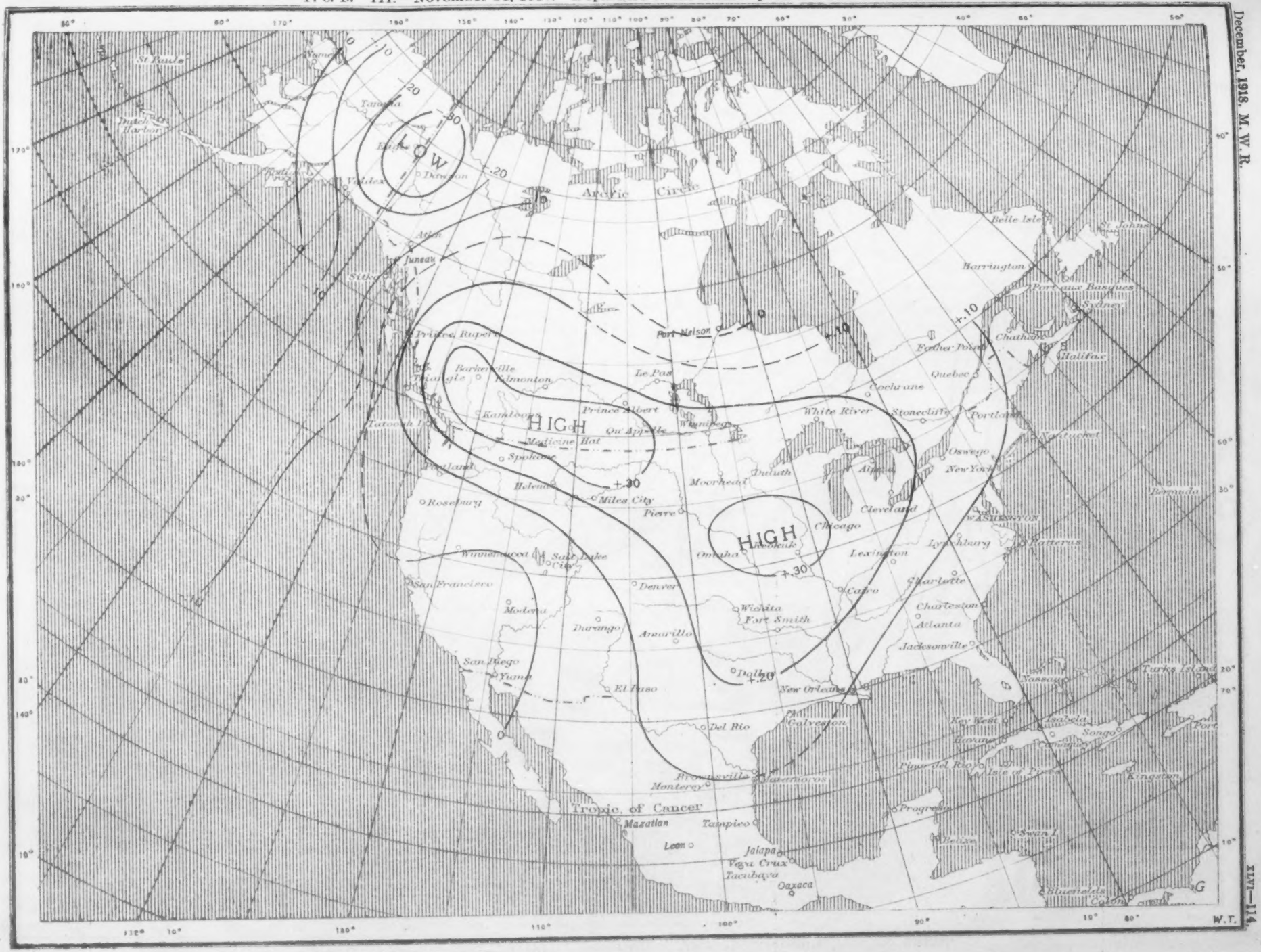
Chart XI. Earthquakes of 1918.

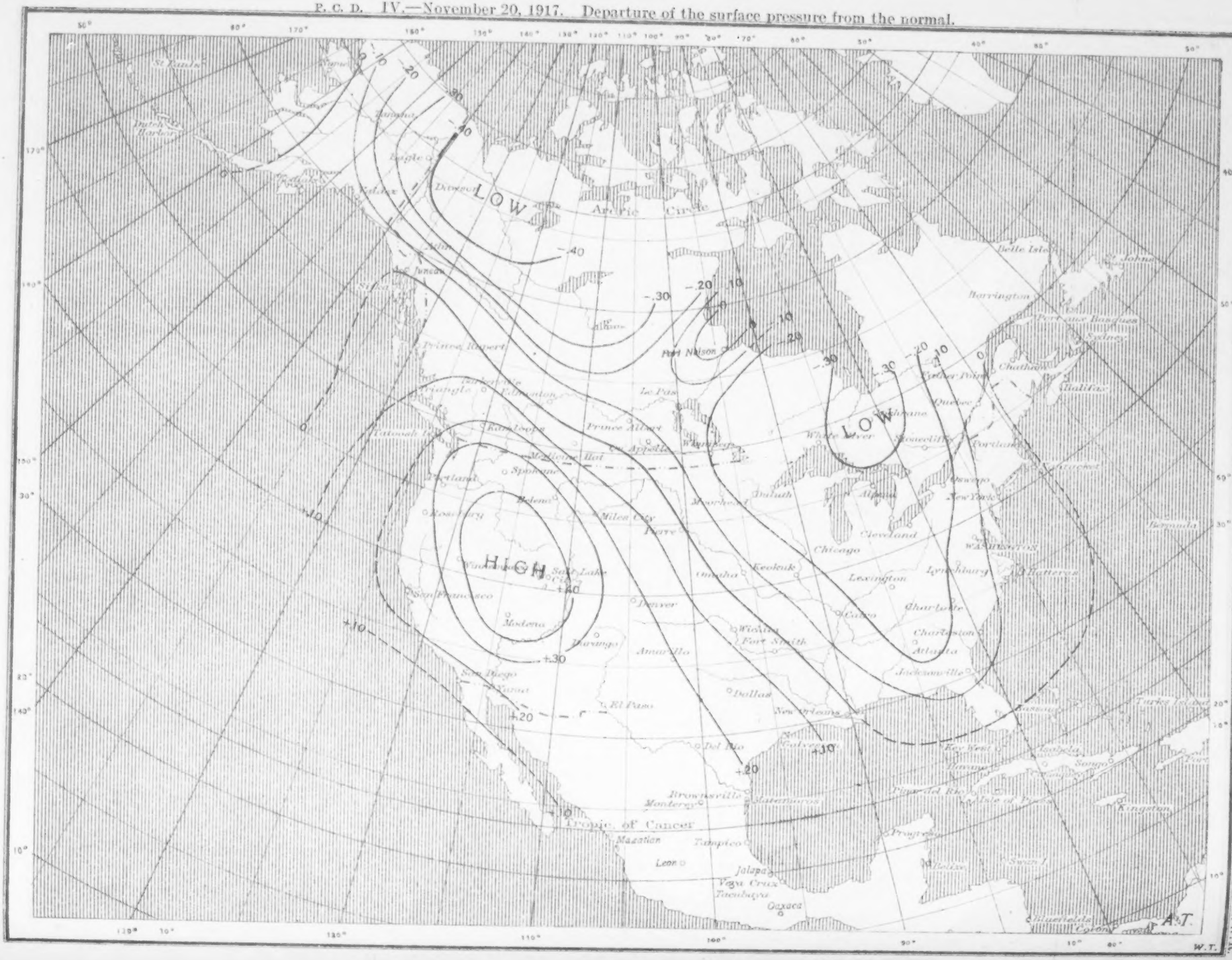
P. C. D. I.—November 2, 1917. Departure of the surface pressure from the normal. 8 a. m., 75th meridian time, except as indicated in the text.



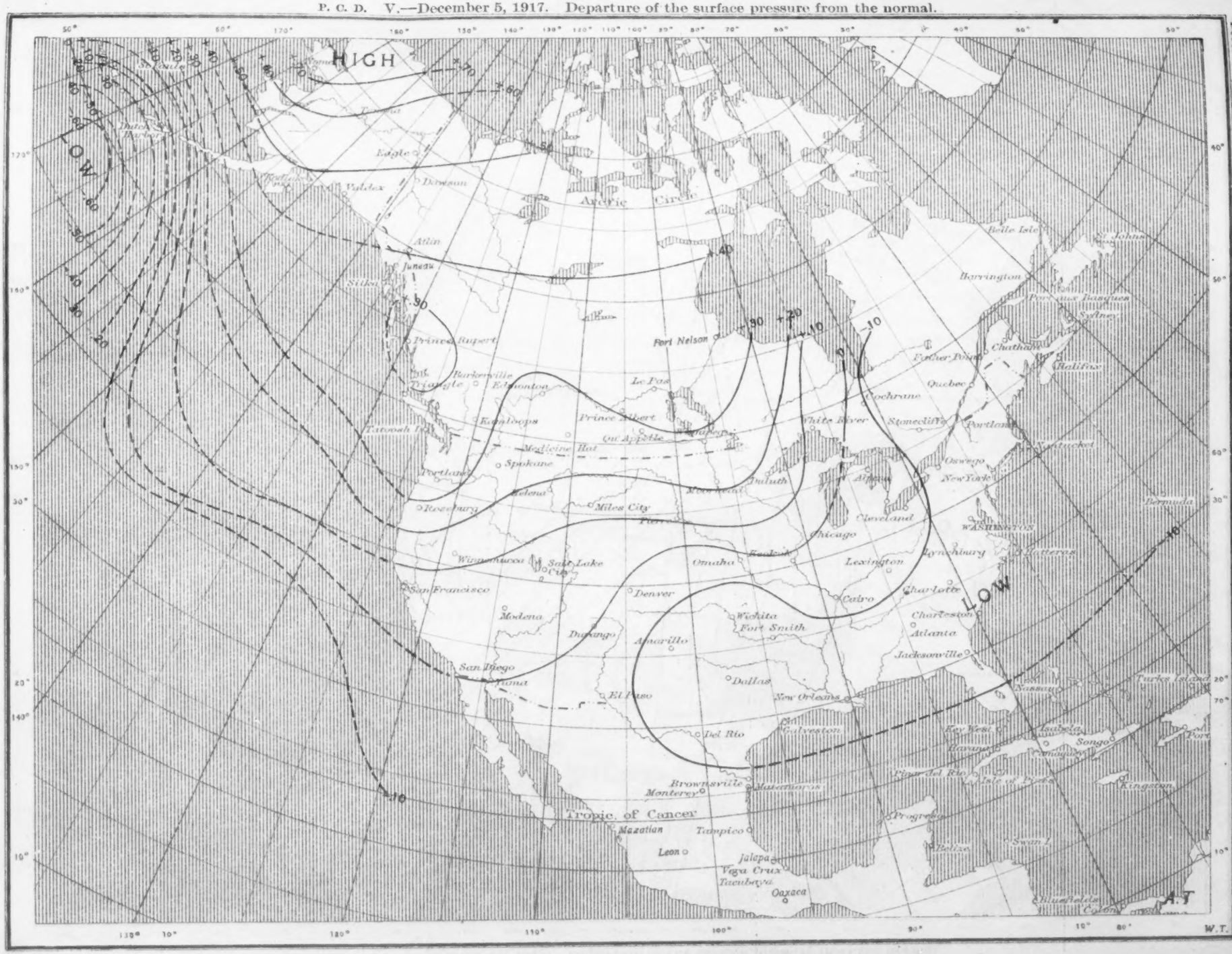

LOW
-.20
-.10
0
+.10
+.20
+.30
+.40
HIGH
LOW
-.20
-.10
0
+.10
+.20
+.30
+.40
Arc. Pic. Circle
Tropic of Cancer
St. Paul
Dutch Harbor
Juneau
Prince Rupert
Port Nelson
Belle Isle
Harrington
Halifax
Medicine Hat
Spokane
Portland
Helena
Miles City
Pierre
White River
Cochrane
Stonecliffe
Cleveland
Chicago
Bermuda
Winnemucca
Salt Lake City
San Francisco
Denver
Omaha
Keokuk
Lexington
Cairo
Charlotte
Charleston
Atlanta
Jacksonville
Modena
Durango
Amarillo
Wichita
Fort Smith
Dallas
San Diego
Yuma
El Paso
Del Rio
New Orleans
Brownsville
Monterey
Mazatlan
Tampico
Leon
Jalapa
Vera Cruz
Tuxtepec
Oaxaca
Key West
Havana
Progreso
Belize
Swan
Turks Island
W.T.
W.T.

P. C. D. III.—November 14, 1917. Departure of the surface pressure from the normal.

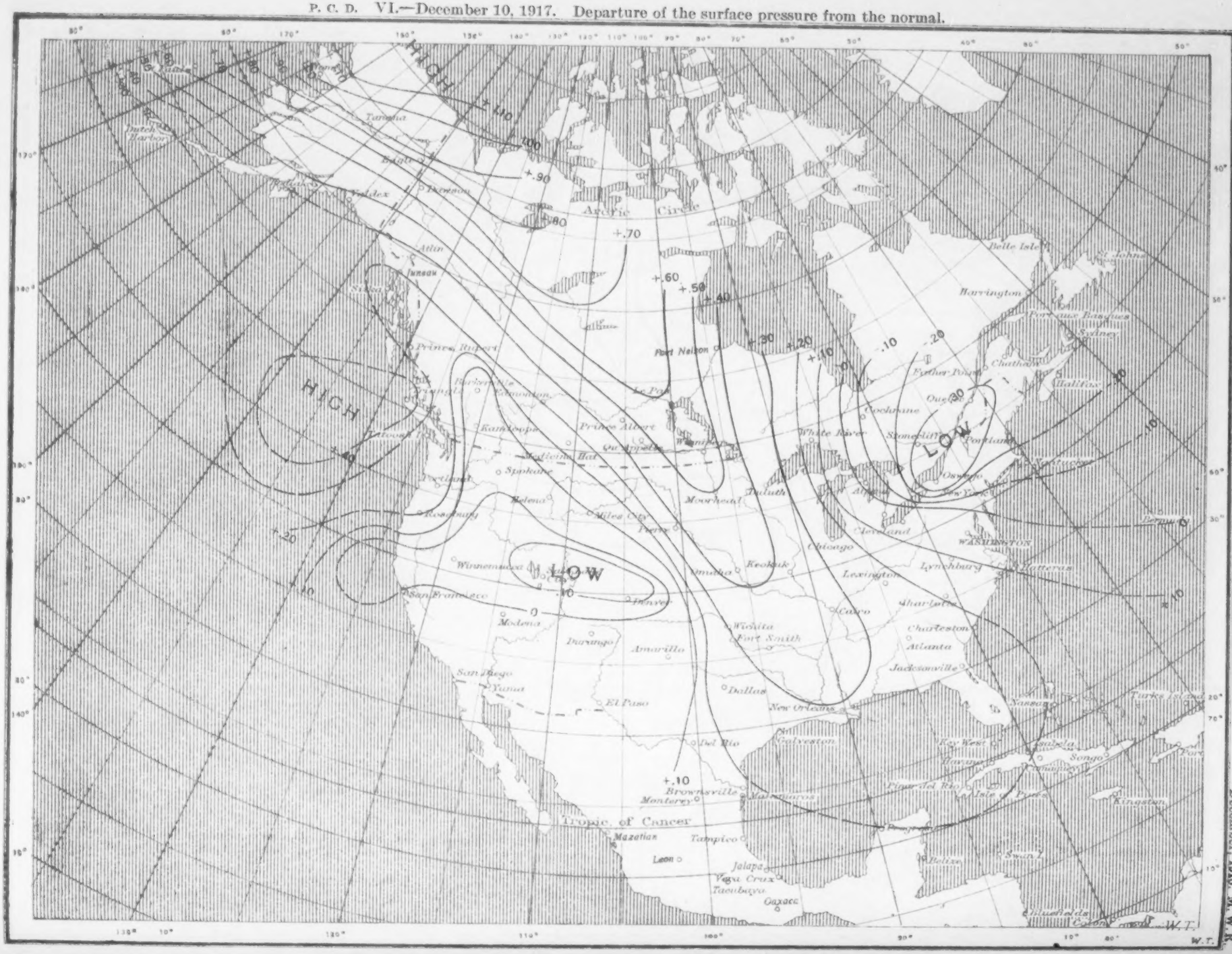



LOW
HIGH
LOW
-40
-30
-20
-10
0
+10
+20
+30
+40
Arctic Circle
Tropic of Cancer
Dawson
Juneau
Prince Rupert
Fort Nelson
Le Pas
Prince Albert
Winnipeg
Moosejaw
Medicine Hat
Spokane
Portland
Boise
Rosebury
Salt Lake City
Pierre
Duluth
Marquette
Chicago
Cleveland
Buffalo
Toronto
Ottawa
Montreal
Quebec
Halifax
Omaha
Keokuk
Denver
Lexington
Charlotte
Cairo
Wichita
Fort Smith
Amarillo
Atlanta
Charleston
Jacksonville
Modena
Durango
San Diego
Yuma
El Paso
Dallas
New Orleans
Del Rio
Brownsville
Monterey
Matamoras
Tampico
Mazatlan
Leon
Jalapa
Vera Cruz
Tacubaya
Oaxaca
Key West
Havana
Kingston
Bermuda
Belle Isle
St. John's
Harrington
Father Point
Chatham
Yarmouth
Sydney
Port aux Basques
Prince Edward Island
Anticosti
Hatteras
Lynchburg
Pittsburg
Parry Sound
Sault Ste. Marie
Port Arthur
Winnipeg
Battleford
Calgary
Edmonton
Fort Simpson
Dawson
Juneau
Sitka
Dutch Harbor
Eagle
Fairbanks
St. Paul
Yukon
Mackenzie
Athabasca
Saskatchewan
Red
Missouri
Columbia
Colorado
Rio Grande
Mississippi
Ohio
Tennessee
Hudson Bay
Labrador
Greenland
Iceland
Europe
Asia
Africa
A. T.
W. T.

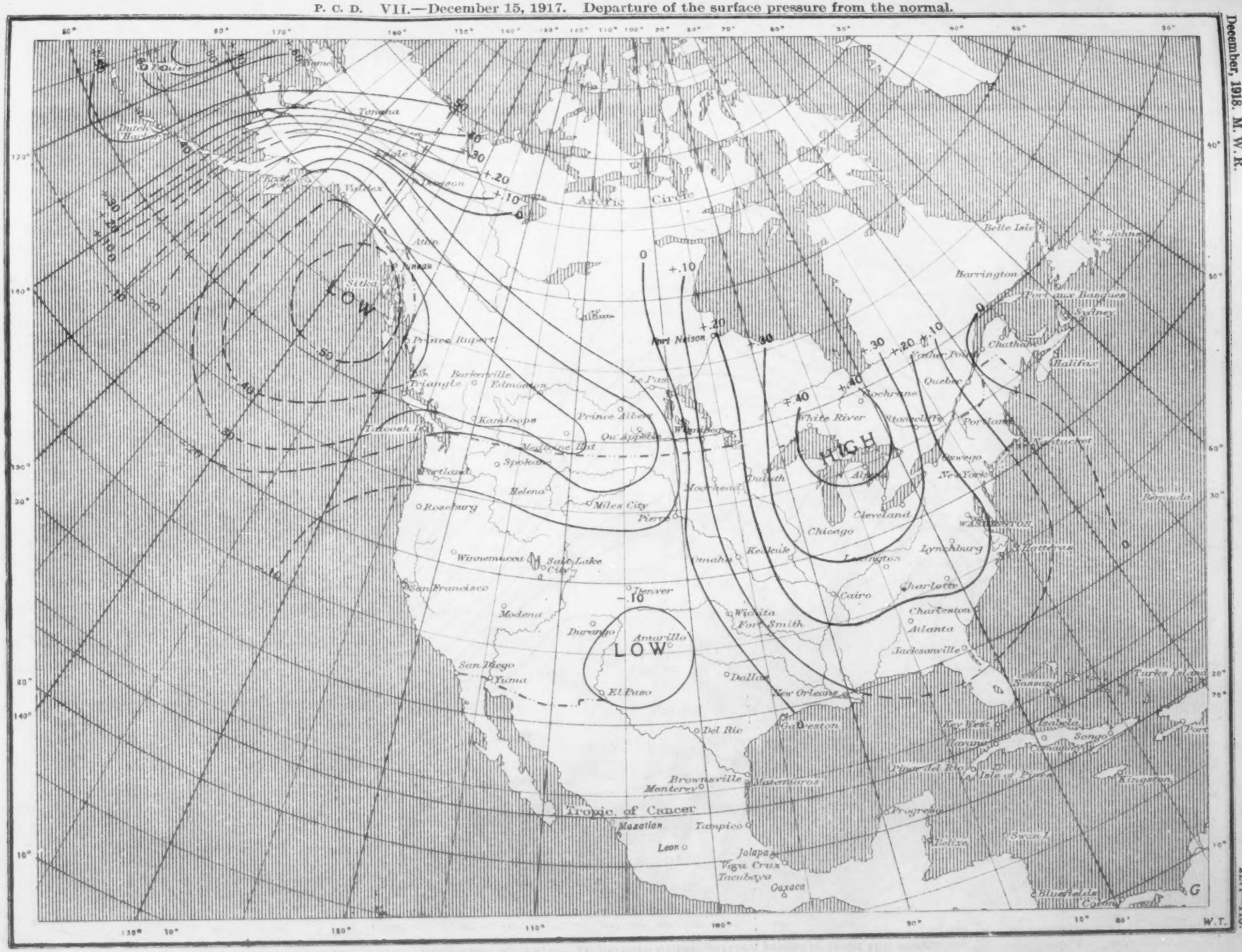
P. C. D. V.—December 5, 1917. Departure of the surface pressure from the normal.



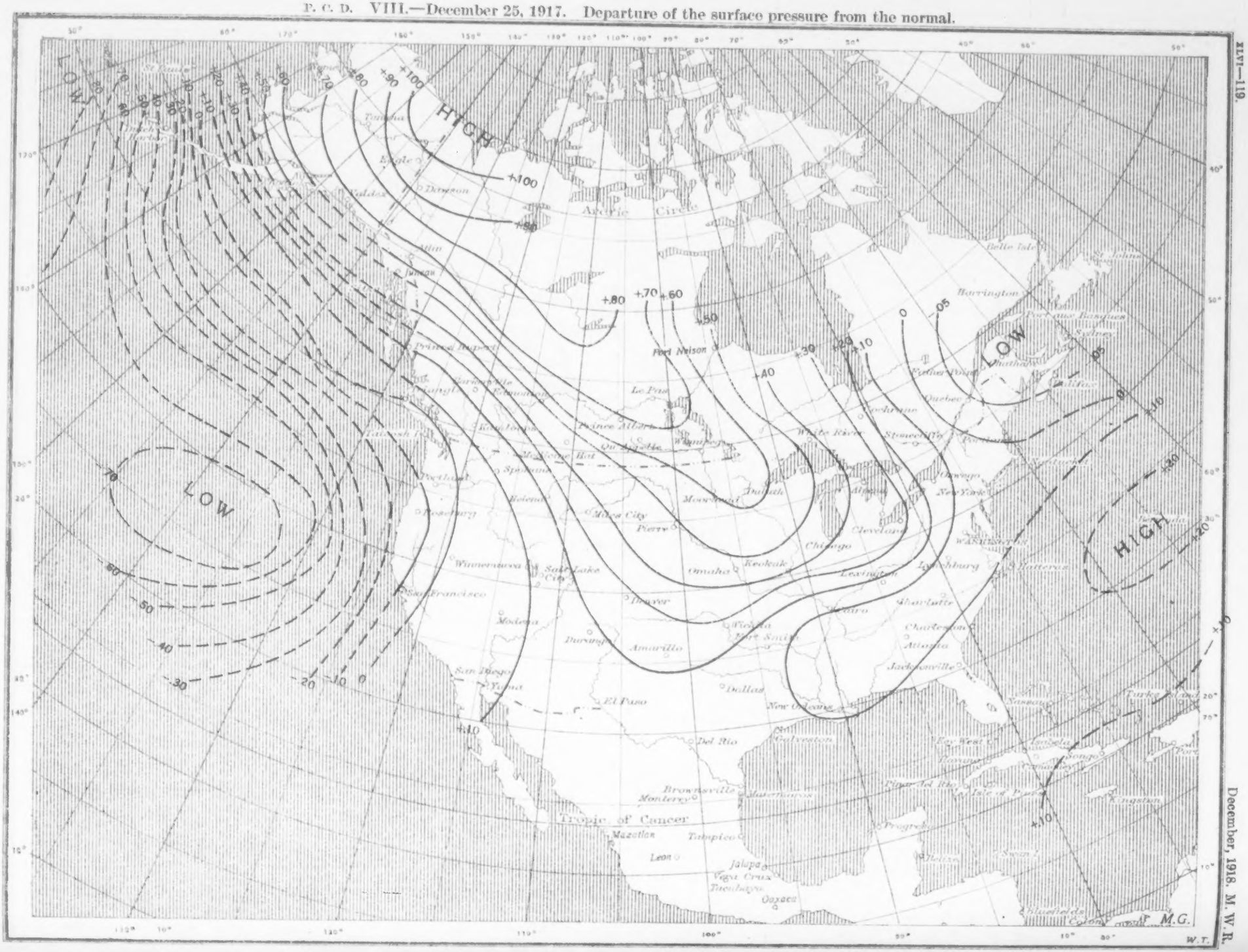
P. C. D. VI.—December 10, 1917. Departure of the surface pressure from the normal.

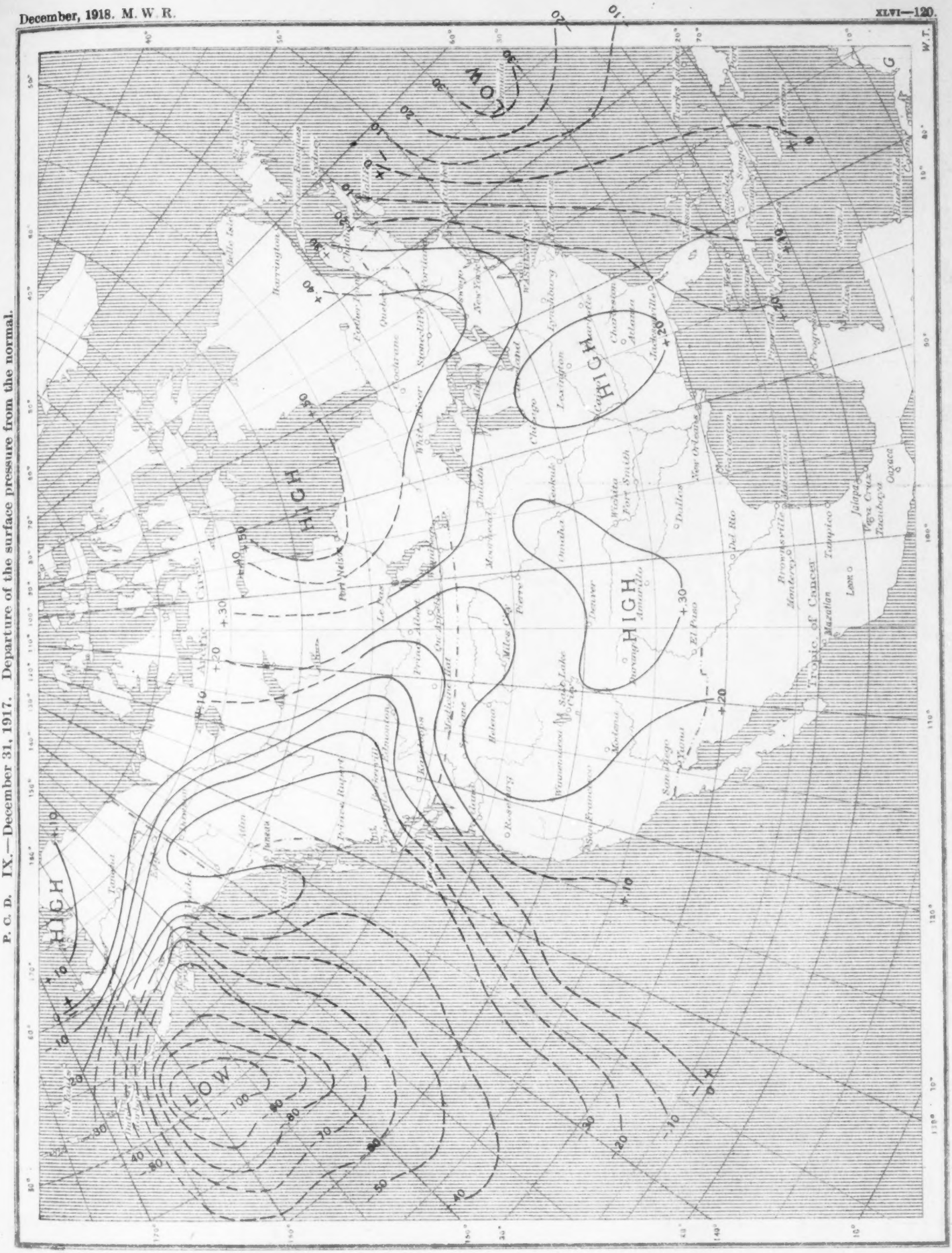


P. C. D. VII.—December 15, 1917. Departure of the surface pressure from the normal.



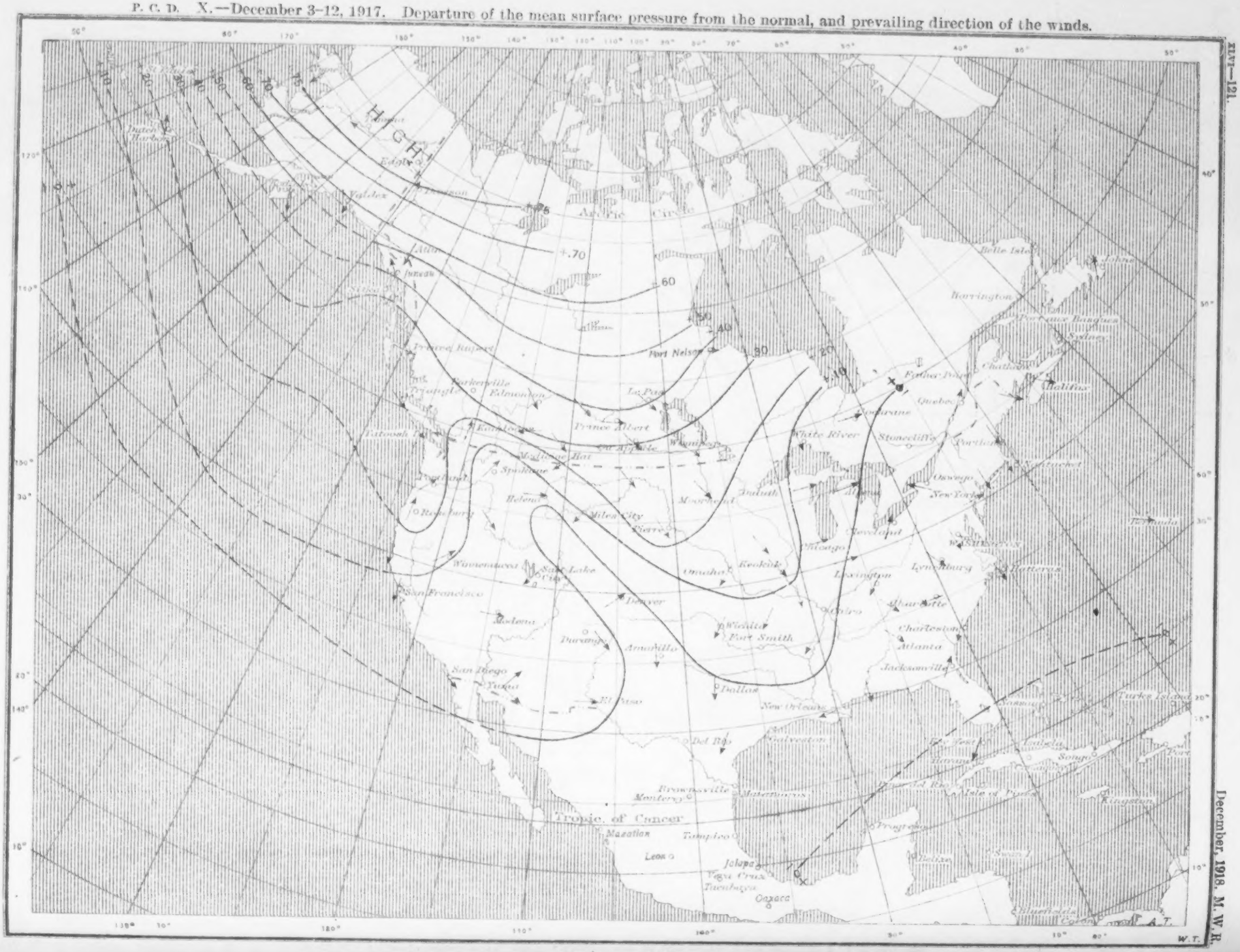
P. C. D. VIII.—December 25, 1917. Departure of the surface pressure from the normal.



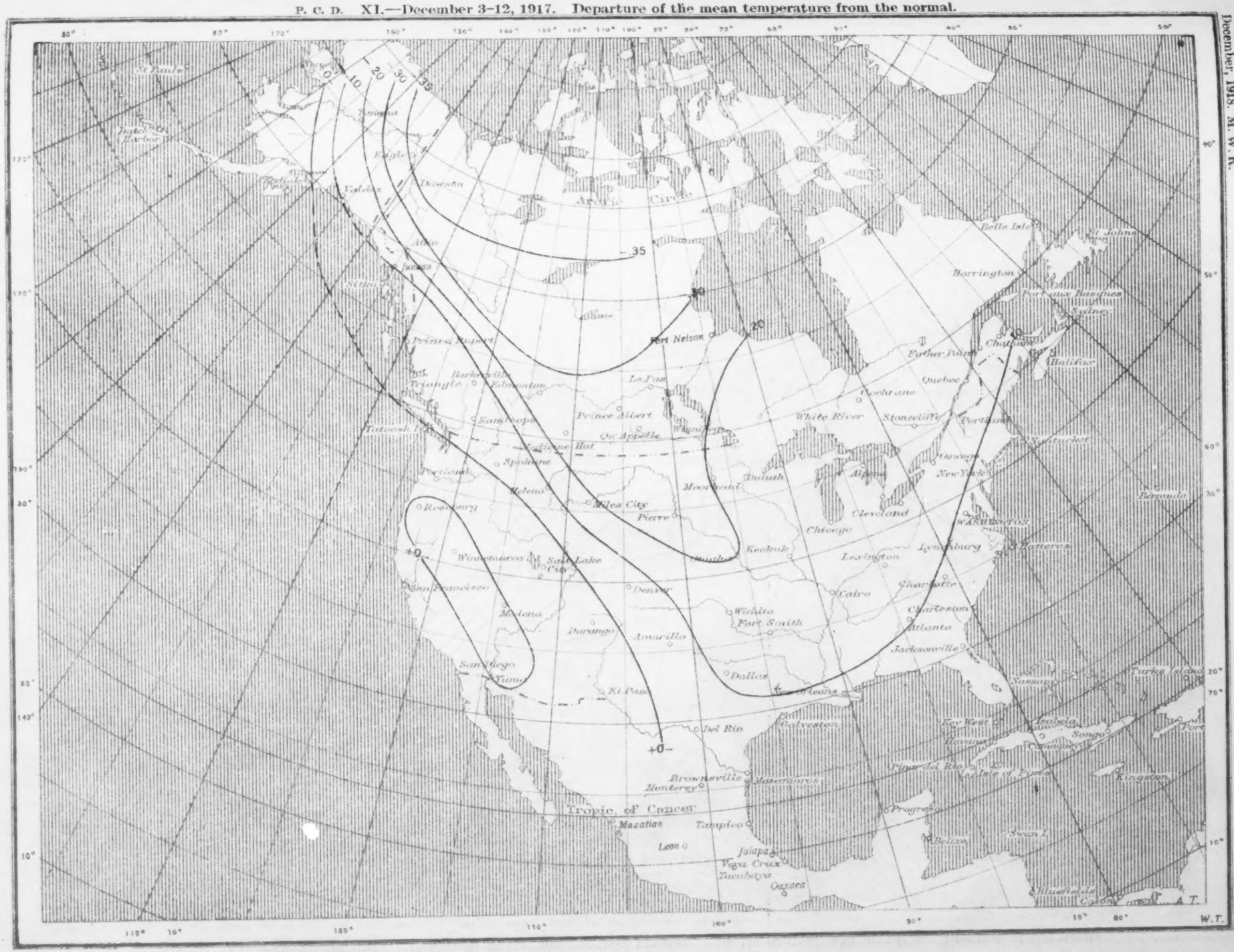


P. C. D. IX.—December 31, 1917. Departure of the surface pressure from the normal.

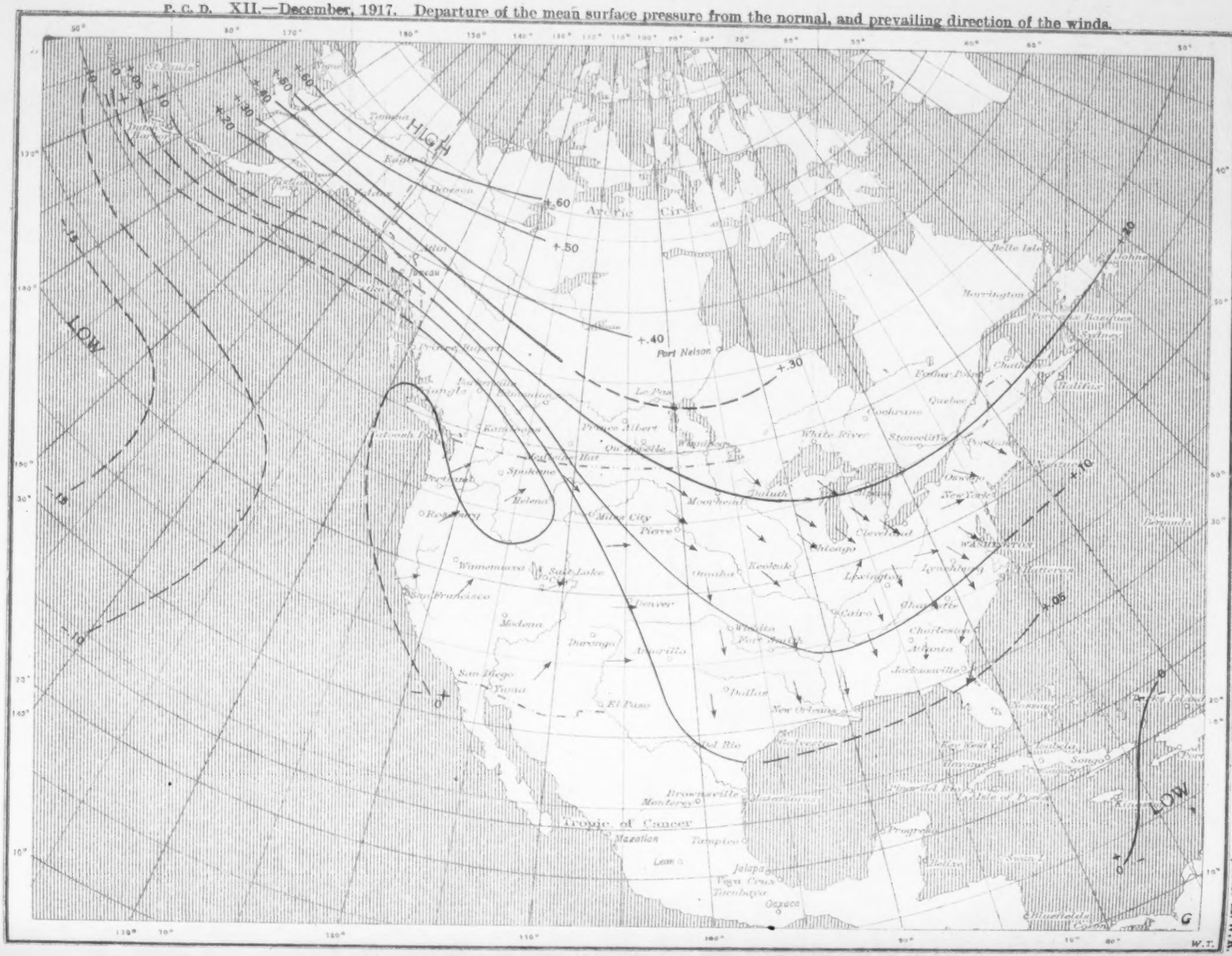
P. C. D. X.—December 3–12, 1917. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.



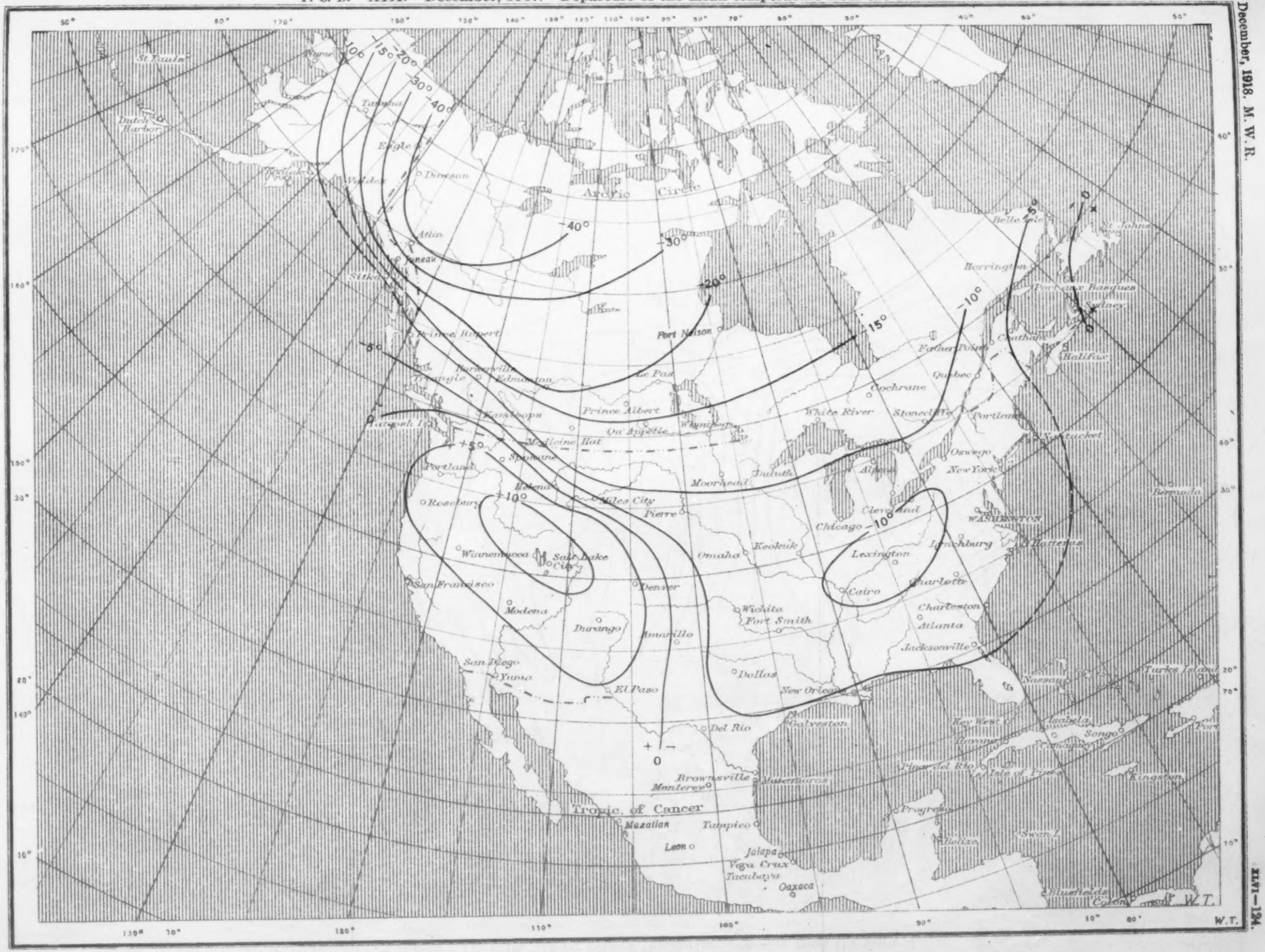
P. C. D. XI.—December 3–12, 1917. Departure of the mean temperature from the normal.

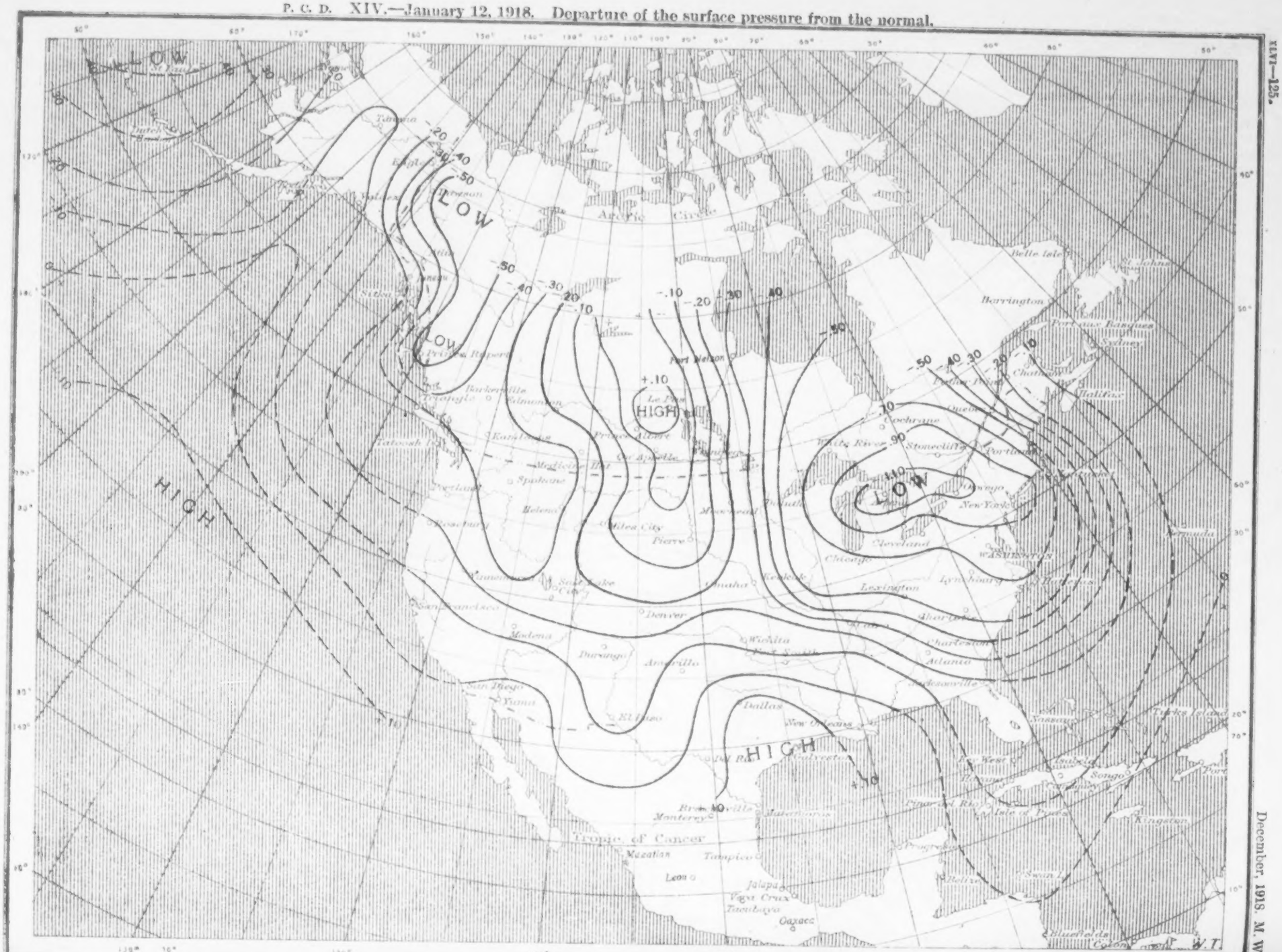


P. C. D. XII.—December, 1917. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.

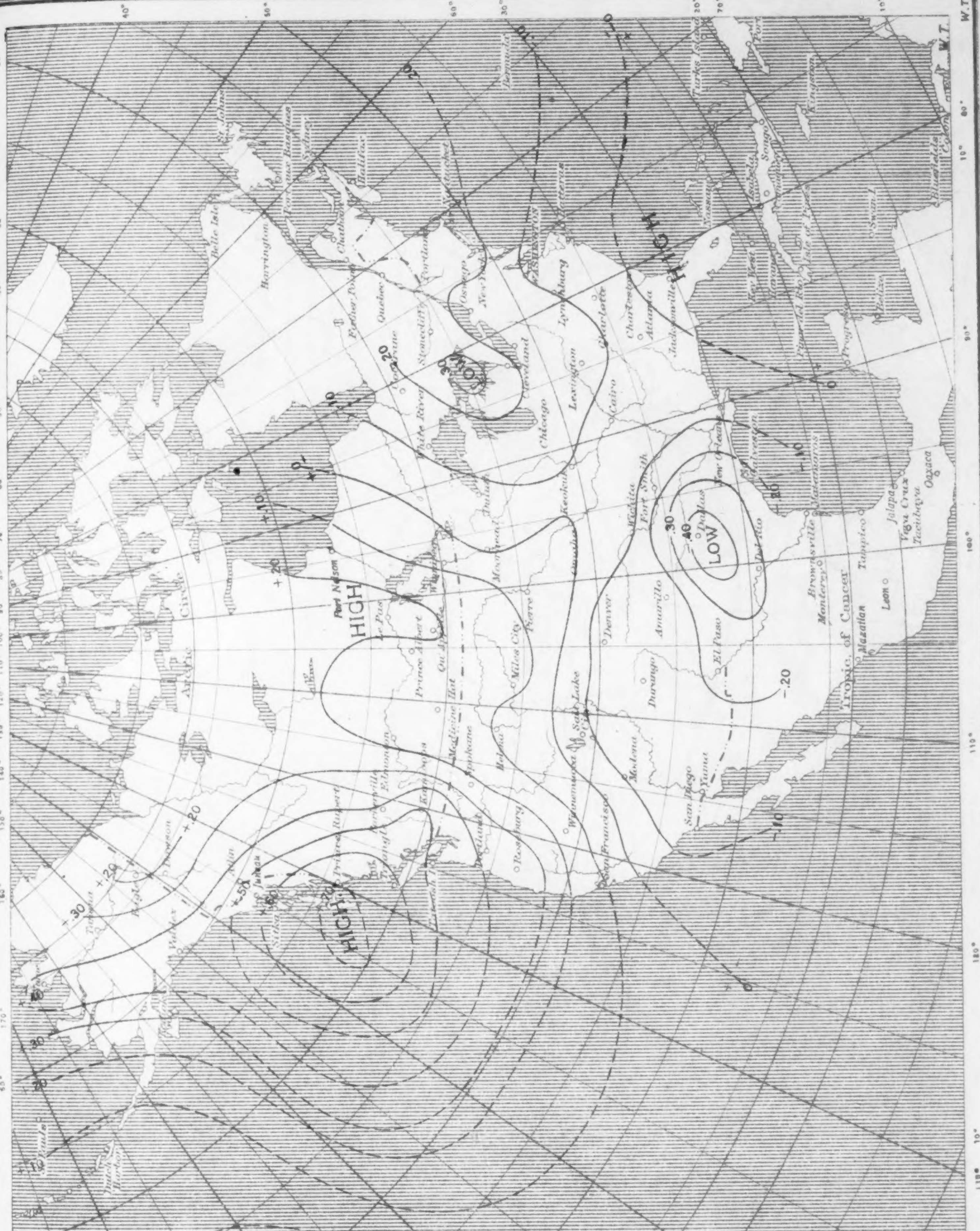


P. C. D. XIII.—December, 1917. Departure of the mean temperature from the normal.

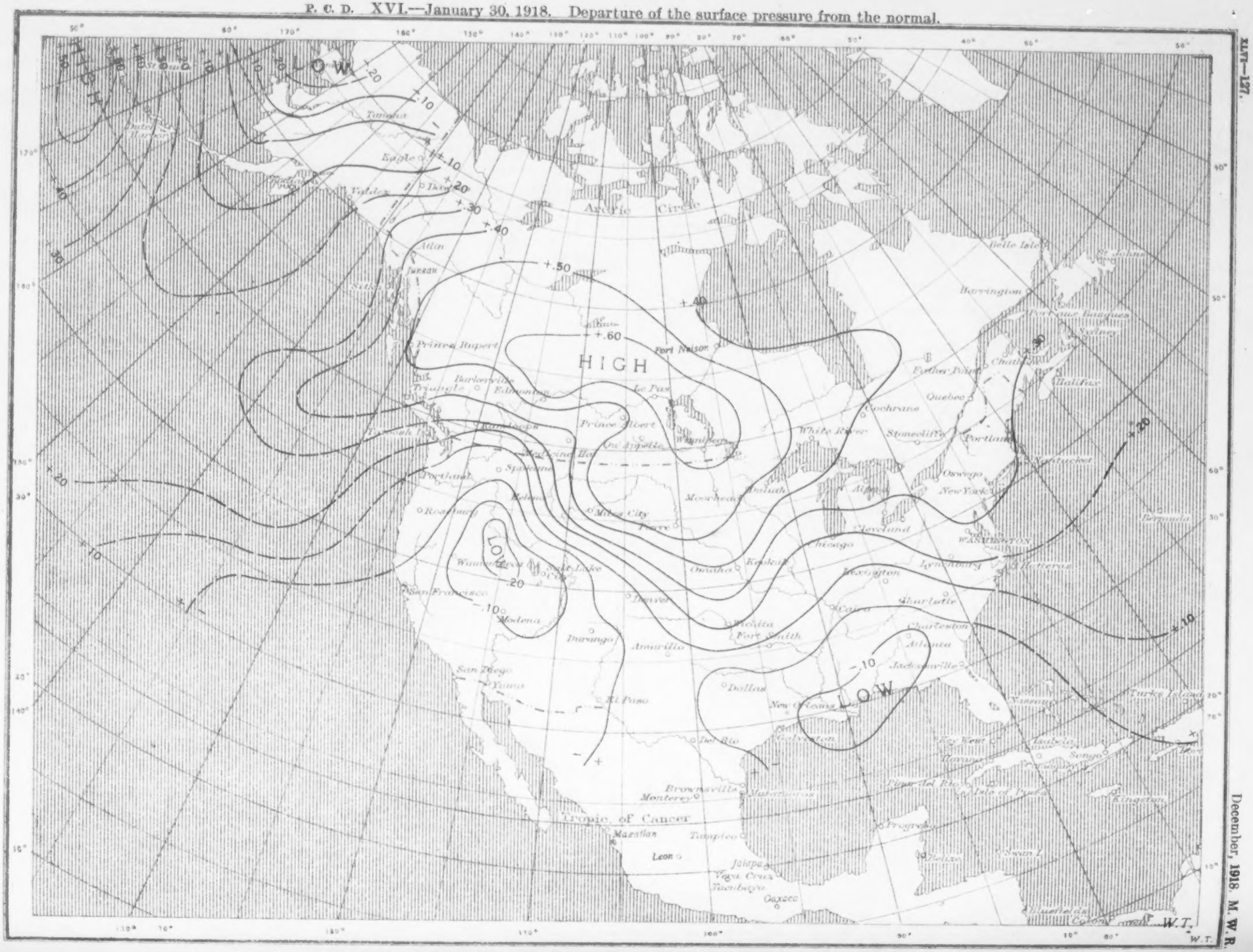



LOW
LOW
LOW
HIGH
HIGH
HIGH
-.10
-.20
-.30
-.40
-.50
+.10
+.10
Tropic of Cancer
Arctic Circle
WASHINGTON
Bermuda
W. T.

P. C. D. XV.—January 19, 1918. Departure of the surface pressure from the normal.



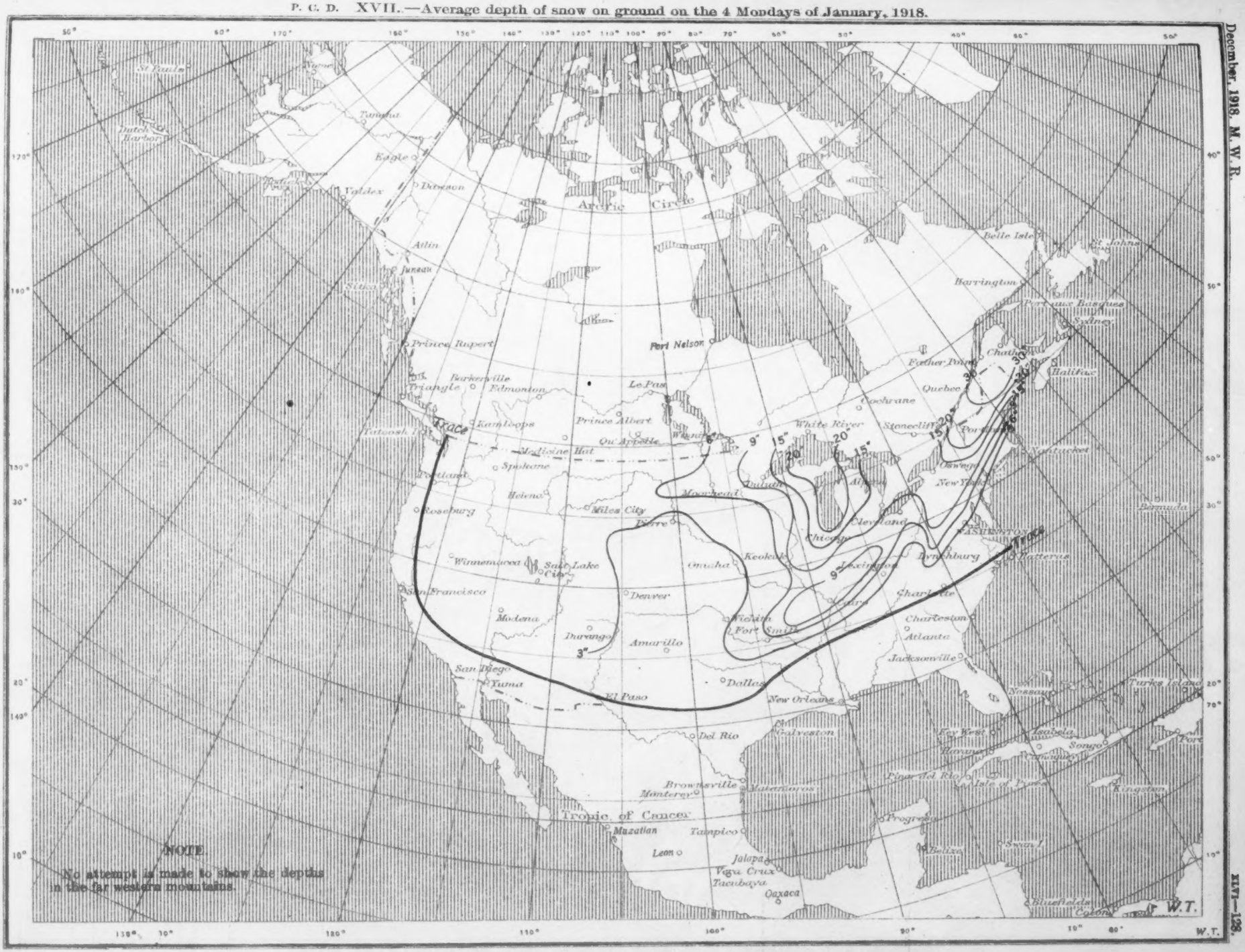
P. C. D. XVI.—January 30, 1918. Departure of the surface pressure from the normal.



XLVI—127.

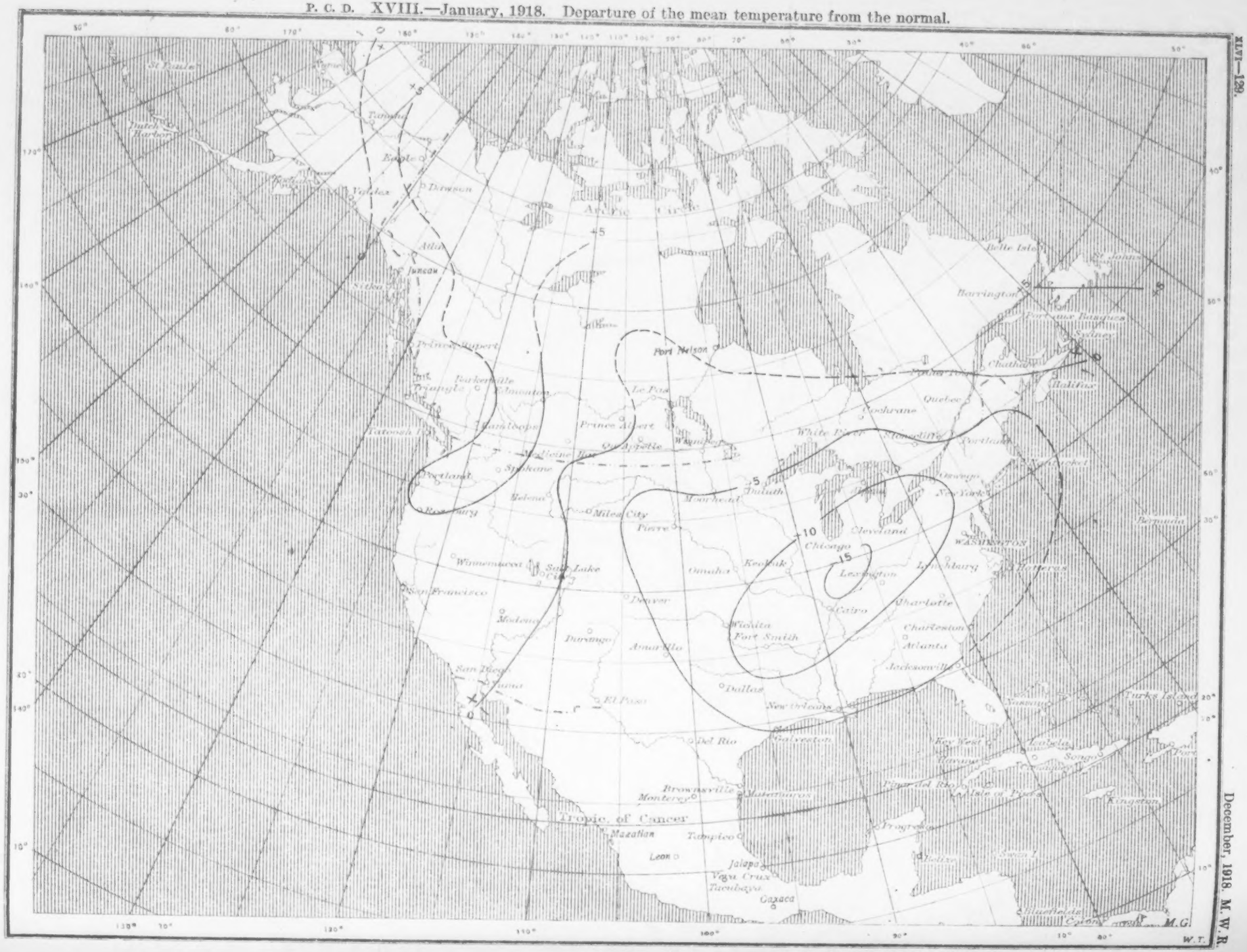
December, 1918. M. W. R.

P. C. D. XVII.—Average depth of snow on ground on the 4 Mondays of January, 1918.

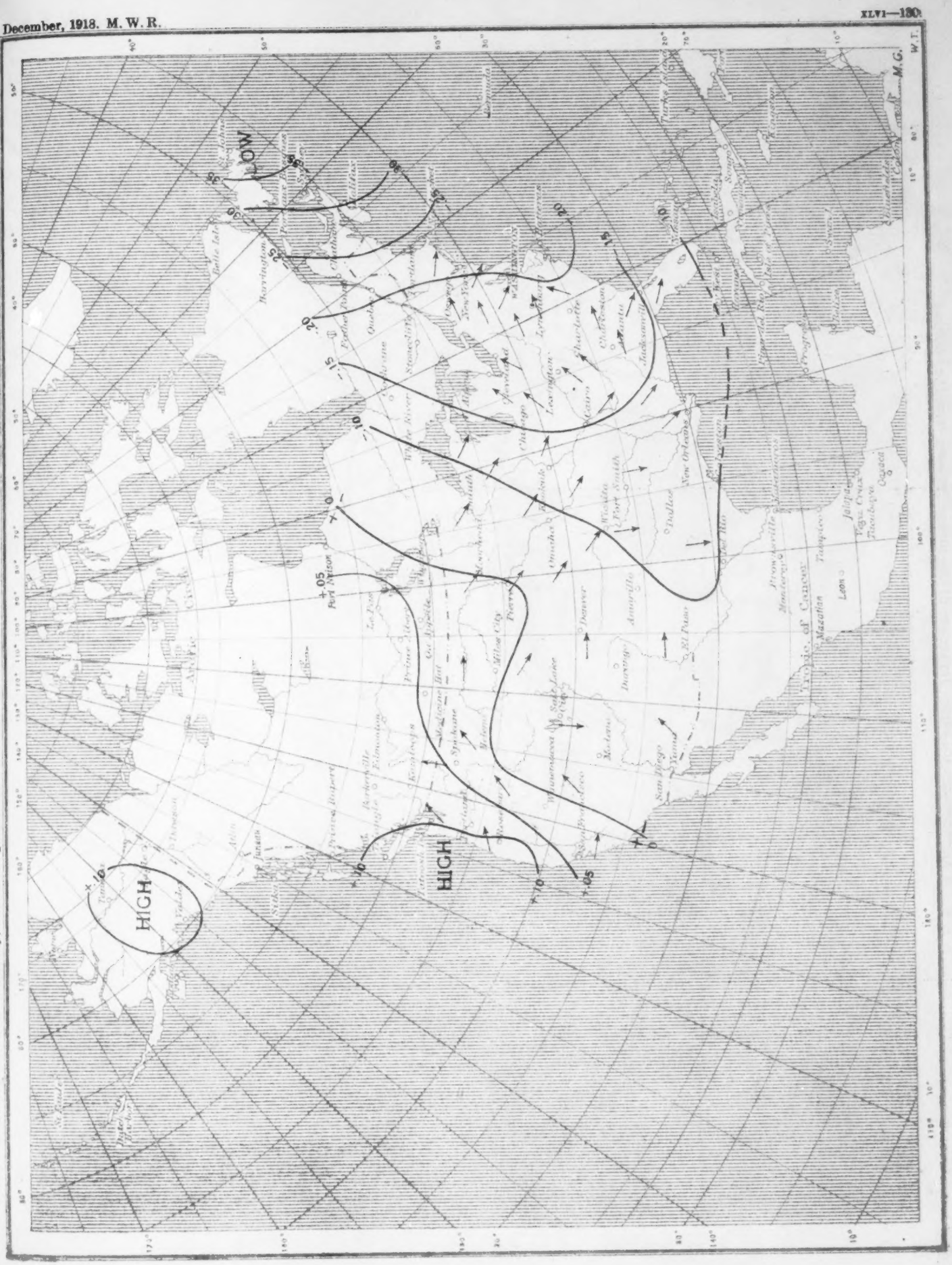


December, 1918. M. W. R.
XLVI—128.

P. C. D. XVIII.—January, 1918. Departure of the mean temperature from the normal.

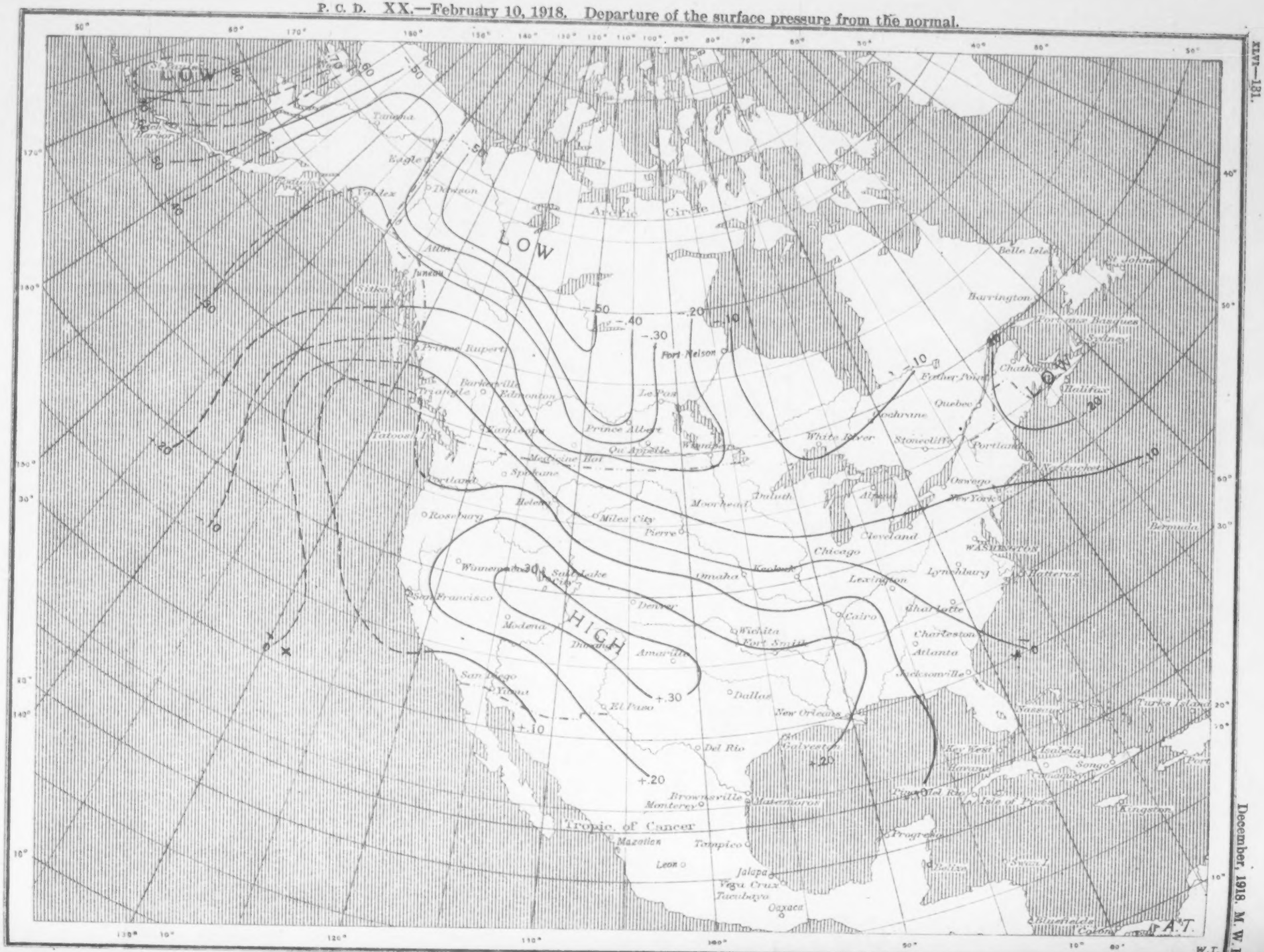


XLVI—129.
December, 1918. M. W. R.

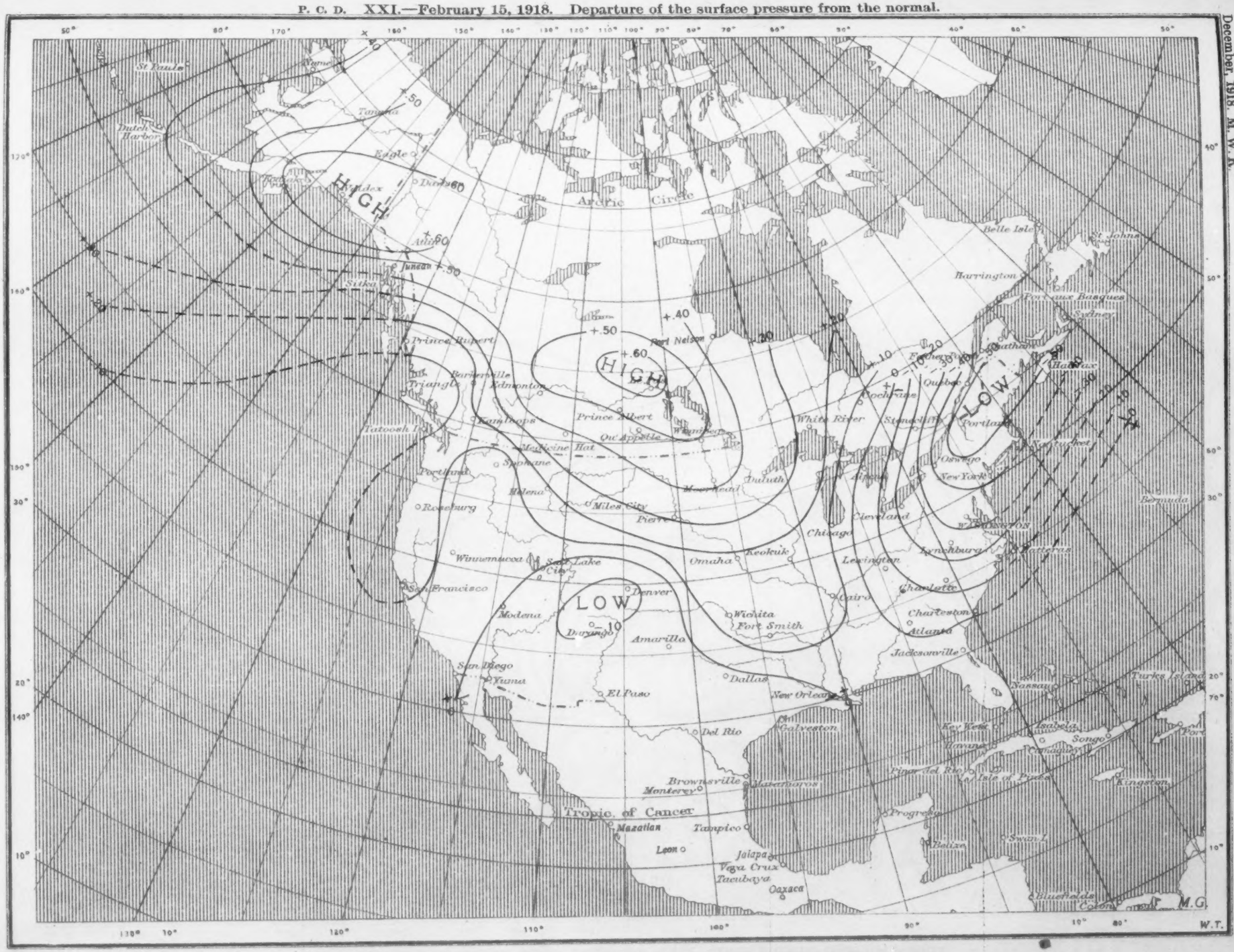


F. C. B. XIX.—January, 1918. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.

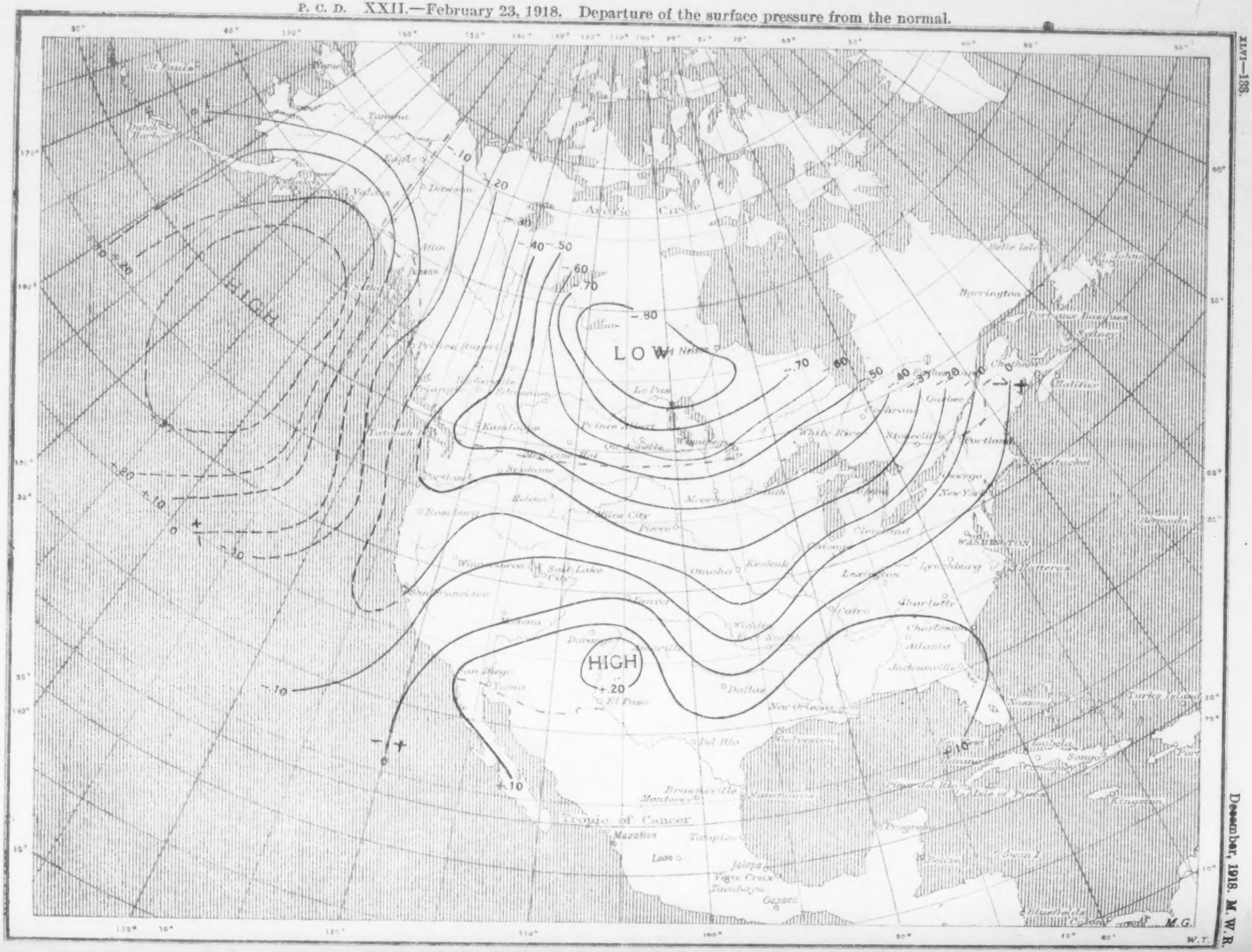
P. C. D. XX.—February 10, 1918. Departure of the surface pressure from the normal.



P. C. D. XXI.—February 15, 1918. Departure of the surface pressure from the normal.



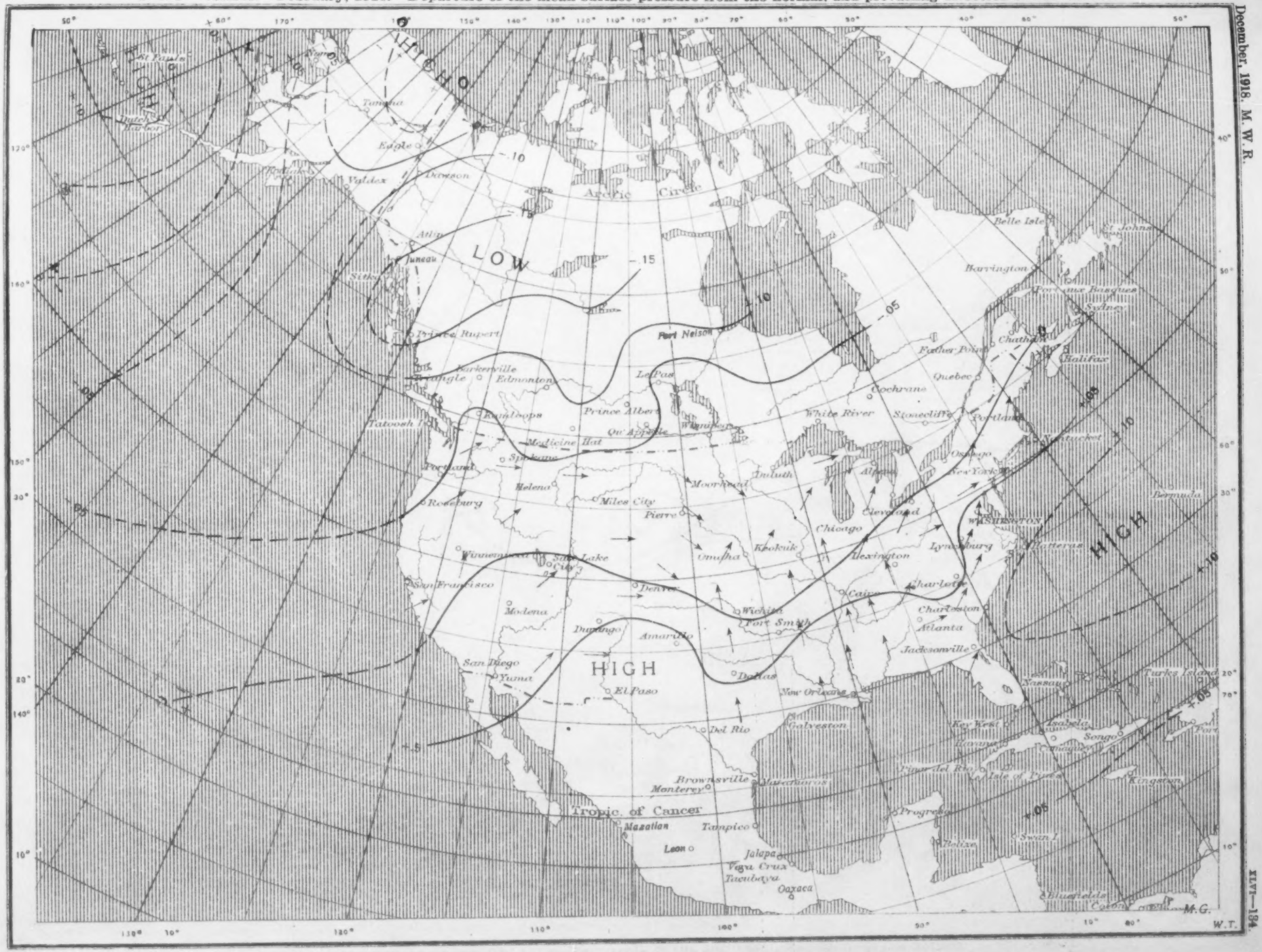
P. C. D. XXII.—February 23, 1918. Departure of the surface pressure from the normal.



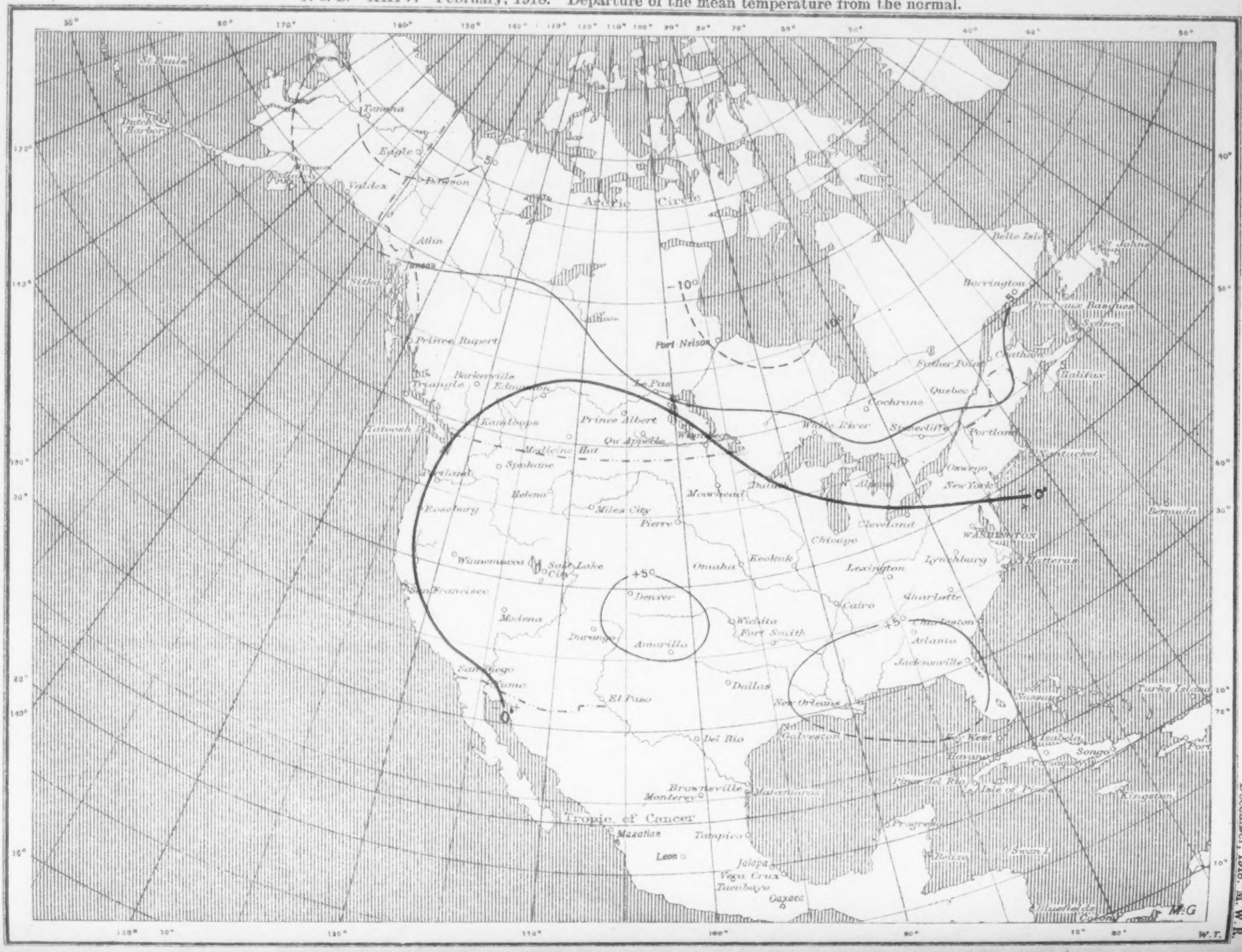
XLVI—153.

December, 1918. M. W. R.

P. C. D. XXIII.—February, 1918. Departure of the mean surface pressure from the normal, and prevailing direction of the winds.



P. C. D. XXIV.—February, 1918. Departure of the mean temperature from the normal.



DETAILED CLIMATOLOGICAL DATA.

Detailed climatological data for the United States and its outlying territories are collected and published in the monthly reports "Climatological Data" issued at the following Section Centers by the respective officials in charge. They may be secured from the *Superintendent of Documents, Government Printing Office, Washington, D. C.*

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Arkansas	Little Rock	Harvey S. Cole.	New Jersey	Trenton	G. Harold Noyes.
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